MEMBER WALLIS: Wasn't it the claim of the previous speaker that really this blue thing is inside the red, and it is all taken care of, and that we don't need to do anything?

DR. WOOD: And that is not the case. I think that the understanding, partially motivated by the need for additional clarity in the guide, may have left an uncertainty about whether or not this was solely to address the 10 CFR 50.49 kind of application, and that was not the intent of the guide.

And I think if it is interpreted that way, then some of the claims of the speaker makes sense. But we think that it was just a matter of a lack of clarity, and we hope that this revision has addressed that.

One of the other issues that was brought up in the public comments was what was in the version of the draft guide that went out for public comment did not make a very effective case for why are these things different.

Part of that is because those of us who understand the technology and have been dealing with it a long time just simply accept that fact, and I will have to admit that we were not very rigorous in trying to identify all the different differences.

MEMBER WALLIS: But what is the hang-up? I mean, if you put a computer in smoke, it is going to be a different problem than putting some switch gear in smoke.

DR. WOOD: Right.

MEMBER WALLIS: What is the hang-up about saying you have a new problem?

DR. WOOD: Well, you would have to ask the commenters, but what we did is try to expand the discussion so that we were much more precise in what the differences were. And these are some of the differences, some functional, and some hardware.

And if you are talking about an analog piece or analog module that is performing one function, its loss is not the same as the loss of a microprocessor performing many functions.

And then there is the issue of digitizing what had been a continuous application of function in a distributed or let's say in a channel. There is the sequential execution of function, and then as far as hardware goes, there is some differences; more susceptibility for the current integrated circuit technology for radiation tolerance than most of the analog components.

There is also an increasing level of complexity in higher circuit density, which could have some effect on environmental susceptibility, and higher clock speeds and lower voltages could increase or do increase the potential susceptibility to electrical and EMI kind of events.

MEMBER WALLIS: Isn't the difference -- and this is sort of an aging system, which is different from the old systems, and it is processing information, and therefore has a way of distorting the information and confusing in a way that was not there before?

DR. WOOD: I think the main difference has to do with the level of understanding of what is going on under the surface. I think people have a pretty clear understanding of the physics behind some of the analog modules and how is it going to respond to different environmental conditions.

But when you are talking about a microprocessor, and you can talk to our colleagues that also deal with software V&V, understanding how that microprocessor is going to respond with all of those number of transistors is maybe a little more complex and are harder to deal with.

The applications of microprocessor-based systems for reactor protection systems tend to be functionally the same. That is what the analog components are, although we have an example in one of our background viewgraphs.

MS. ANTONESCU: It is an illustration of an analog channel and a digital channel, and you can see how several of the instruments are being replaced by a microprocessor.

MEMBER SIEBER: Is that in our package?

MS. ANTONESCU: No it is a back-up slide.

DR. WOOD: We can provide this.

MEMBER SIEBER: Yes, any slide that you use --

DR. WOOD: Any slide that we use, we will provide to you later. This one in particular is just illustrating a simple instrument string within an analog reactor protection system, versus what is basically the full reactor protection system for the advanced boiling water reactor.

And one way to look at it is that all of these functions are performed right there. So everything that you do here can be done right there, with the exception of that some of the calibration is probably distributed into the remote multiplexing unit.

Now, that is not on one microprocessor. They tend to break it up so that there is some functional diversity, so that if you lose one microprocessor, you still have functional diverse trip signals within that channel.

The other thing that the advanced boiling water reactor protection system adds is inner-channel communication. Whereas before all of the trip logic voting occurred in the relays, this duplicates it. It performs it twice in the trip microprocessor-based unit.

And then in your solid state relays, and so it just performs it twice, but there is inner-channel communication through optical isolation, and optically isolated links.

But that just illustrates a current version, and it is implemented in Japan, and it is being implemented in Taiwan, and if the ABWR is chosen for the MP 2010 program, it will be implemented here.

This design has been reviewed by the NRC staff for the design certification of the ABWR.

MEMBER SIEBER: let me ask a question to demonstrate my ignorance. I am aware of a situation where a microprocessor-based instrument had a counter in it, which was basically a timer, and because of spikes on the emergency buses that were caused by relays closing, it would cause that timer to reset.

Now what regulatory guide covers that? Is that 1.180, or is it covered at all?

DR. WOOD: It is covered through the provisions of 1.180 dealing with surge, surge withstand testing, and also through conducted EMI.

MEMBER SIEBER: Yeah, and on the other hand if it doesn't fail, and it just becomes confused for a second and fails to perform the function.

DR. WOOD: Right.

CHAIRMAN BONACA: Right.

MEMBER WALLIS: So the electromagnetic environment is part of your environment?

DR. WOOD: It is part of the environment, and the way that this guide handles it, this proposed guide handles it, is to identify it and make sure that it is considered, and then point to the appropriate guidance for how to address it.

And in that guidance, Reg Guide 1.180, it addressed electromagnetic compatibility more than just qualification. It addresses design and implementation practices, as well as essentially susceptibility practices, and it also addresses how that system may affect that environment through emissions testing.

One of the reasons that there were several comments dealing with some positions that have been subsequently deleted is we took a similar approach in the first version of this guide, and dealt with environmental compatibility, rather than just strictly environmental qualification.

And so there were things about implementation and design, and looking at lower levels within the system at the components that were indeed expanding the scope of if you called it environmental qualification. It was really environmental compatibility.

They weren't presented as required things to do. They were instead presented as information that can supplement the evidence, but because the comments illustrated that they were being understood as requirements, those positions were deleted.

So that information, which is useful information, is maintained in the associated

NEUREGs. I realize that we are a little limited on time.

MEMBER SIEBER: Right.

DR. WOOD: So I will just skip through each of the positions within the guide and talk about the technical basis for those provisions. The main thing is the endorsement of the current national and international standards for environmental qualification, as being appropriate for application for microprocessor-based --

MEMBER WALLIS: And the industry objects to it?

DR. WOOD: No.

MEMBER WALLIS: If that is not a bone of contention, then focus on what the bones of contention are, and maybe we could help.

DR. WOOD: Okay. Well, actually we hope to have to have addressed all the bones of contention.

MEMBER WALLIS: And so they have accepted them then?

DR. WOOD: Well, no.

MS. ANTONESCU: They have never seen one resolution once they are implemented.

DR. WOOD: I discussed these things at a

working group meeting of our EEE323 for the revision of EEE323, and I have discussed these things at conferences, but we have not had until today a public meeting addressing this guide. So the position here on --

MEMBER LEITCH: As I understand it, you can use either one of these standards, but not cherry-pick.

DR. WOOD: That's right.

MEMBER LEITCH: And you use one in its entirety.

DR. WOOD: That's right. I didn't put the words on this viewgraph that said no mixing and matching. You can't just say that I want this out of IEC and I want this out of IEEE.

MR LEITCH: We were -- can you say without taking a whole lot of time just what are the major differences between the U.S. and the European standard?

DR. WOOD: The European standard provides a lot more detailed guidance, and it breaks the test sequence up into three major categories, and it allows the user to use different specimens in each of those categories as long as there is no demonstrated relationship.

So that you don't have to have the same specimen going through every test. The European standard has some references to other European guides on specific ways to conduct tests. So it gives more detailed information there, but for the most part the two standards, we did a detailed comparison of the two standards. They are very much equivalent.

MEMBER LEITCH: I tried to do that, but the version that we got, we only got every other page.

MR. DICKSON: That's because the pages that you didn't get, they were in French.

MEMBER LEITCH: Oh, okay.

DR. WOOD: So if you could read French, then it might have helped you. So anyway the detailed comparison of the standards is the basis for this position.

And there was also a comparison of the 323- 1983, the current version with the 323-1974 version, which is what the staff had endorsed in the past. Then the environmental qualification of this is the unique characteristics, two points were addressed.

One is that the equipment should be

functioning, and performing its operational activities while being performed, and that is directly out of IEEE 7-4.3.2, which is also endorsed by the staff.

And then the dynamic response of a distributive system under environmental stress should be considered during qualification testing that is consistent with what is in Appendix B and Appendix C of Chapter 7, Chapter 1, in the standard review plan.

MEMBER POWERS: Are you making the point of the previous speaker that this stuff is all covered elsewhere?

DR. WOOD: These things, these two particular things are stated, but maybe not as directly. The standard review plan, while it provides good guidance, is not intended to be guidance to the industry, but guidance to the reviewer.

MEMBER POWERS: It is guidance to the staff and we understand that.

MEMBER WALLIS: I thought you were going to try to cover the unique characteristics of microprocessors?

DR. WOOD: I will tell you how these two

cover those. The first one is that the equipment should be functioning during the tests, which is not stated in IEEE 323, and it covers the functional density because of the complexity of the function that can be performed.

MEMBER POWERS: That is an interesting one. I mean, I like your slide where you pointed out the functional density of microprocessor systems. That is something that I tend to overlook, but then when you say it is functioning during the test, there are so many potential functions of even a simple computer code that you can argue that some of those functions are not being performed in any particular test.

DR. WOOD: Well, I will agree that it is not the same as software verification and validation where you try to perform and see that all of the operational codes execute.

But you can perform the trip comparison where you have trip conditions that would indicate a trip and you have non-trip conditions. You can perform those kinds of functions.

MEMBER POWERS: Sure. I can pick out some particular high level functions, but all the low level ones I can -- I mean, it would be physically impossible to say every single function of this thing has operated in this test.

DR. KORSAH: I think we should make a qualification that this is a hardware situation and not software where V&V. Before you come to this level, you must have done a lot of V&V which incorporates all the different types of testing that you can have, and a 99 percent confidence that this is going to work and those kinds of things.

DR. WOOD: And when you are dealing with a software system, you are dealing with software operating on hardware under whichever environment it is in, and there is an infinite range of combinations that could occur.

But the point here is that this is not a survivability test and demonstrating that it can perform its function. And not to demonstrate that it can perform absolutely every function. And then the dynamic response of a distributed system deals with the sequential execution of function.

If you have information that has to go from this microprocessor across a network to that microprocessor, depending on what kind of handshaking you have in that communication, the effect of the environment on those communication interfaces can affect the overall system response.

And it is not a new requirement, because there is a lot of information about you need to look at the dynamic response of your system, and this is just making sure that you don't forget it.

Just because you can't test a distributed system like the ABWR system as a whole and all in one chamber, doesn't mean that you shouldn't do an analysis accompanying that system.

The environmental effects here, coupled with the environmental effects here, don't add up to a cumulative delay that affect the system response. These are not earth-shaking requirements, if you want to call them requirements. Guidance.

They are just intended to make sure that the users of the guidance is aware that these are two particular issues.

MEMBER WALLIS: What are you thinking of here? I mean, that there is a computer here and a computer there and talking through some kind of a line, and someone comes and operates a welder, and the electromagnetic thing coming out from the weld sends false signals along the line. Is that the kind of thing that you are thinking of?

DR. WOOD: Well, that is one thing that

could happen. The ABWR example that I used, the remote multiplexing units to be in the reactor building, because they are there multiplexing data and sending it then to the location of the control room for the trip calculations.

There is a distributive system, and you can't put it all in one chamber.

MEMBER WALLIS: I have no idea what the test sequence might be for something like that. Maybe we should move on.

DR. WOOD: Okay. The other one which was mentioned was electromagnetic compatibility testing, and the susceptibility of surge to withstand, and this is the worldwide practice, the international practice.

So our position is that it belongs here, and it is being put there in IEEE 323 in the next revision.

MS. ANTONESCU: And the EPRI document 107330.

DR. WOOD: That's true, the EPRI guidance on qualification of PLCs.

MS. ANTONESCU: And it also mentioned in IEEE 7.4.3.2., too.

DR. WOOD: The application locations

were simply intended to streamline the initial determination of do you need to address aging and if you do type testing. And it is not a radical departure, and we tried to look at the information that was being provided by public comments and adjust things that it is much more practical to implement and avoid some of the potential for burden that were illustrated in the public comments.

But basically Location A categories correspond to 10 CFR 50.49 locations. Traditional aging factors must be accounted for in qualification, and that is what Reg Guide 1.189 says. It is consistent with that.

Category C locations are really the new thing, and it is intended to RELAP the position that is in the standard. Category C locations are areas that employ environmental control and it is generally acknowledged that there are not traditional aging factors in those areas.

And so aging is not a necessary step in qualification, nor is the determination of do you have significant aging mechanisms. And then Category B is everything else.

The only thing this does is take the model environments that exist in IEEE 323-1983, and set aside a small subset of locations which correspond to environmentally controlled locations, and says you don't have the burden of trying to determine do I have to address aging. That is the purpose of --

MEMBER POWERS: When you are discussing aging here, are you discussing aging over the course of an event, or over the course of a lifetime of a plant?

DR. WOOD: Over the installed life of the piece of equipment.

MEMBER SIEBER: The difficulty with that is that it is pretty subjective as to how much ventilation you have and so forth. It seems to me that your model environments in Category C are pretty mild.

DR. WOOD: They are.

MS. ANTONESCU: It is a controlled environment.

DR. WOOD: We floated the term benign.

MEMBER SIEBER: On the other hand, it is usually cold in this room, but if I run this computer all day, it is hot.

DR. WOOD: Oh, yes.

MEMBER SIEBER: So it depends on how we

put it into place.

DR. WOOD: That is exactly right. And the purpose of qualification is to verify that the design accommodates the environment and the conditions or the practices are to test your equipment in its installed condition, and to have all the connections that it would have in its installed location.

MEMBER LEITCH: So can you help me here a little bit with EMI and RFI? We have another document which I believe is presently out for public comment, and in fact maybe the public comment period is closed, and I guess within the next month or two we are going to be seeing that here.

Does that intermesh with what you are speaking about here, with the microprocessors?

DR. WOOD: Yes.

MEMBER LEITCH: In other words, is that being revised also primarily to --

MS. ANTONESCU: We are in the process of revising Reg Guide 1.180 regarding EMI/RFI, and I believe that were scheduled to appear in front of you next month to give a presentation.

MEMBER LEITCH: Those modifications are to address microprocessors?

MS. ANTONESCU: No, no.

DR. WOOD: No, because the original version covered analog and digital, and the modifications deal with basically some issues that could not be addressed in the first version because there weren't mature standards that could do that.

There is a more full compliment and the other thing is trying to provide an endorsement of the international, of the IEC standards.

MEMBER LEITCH: Okay. Thanks.

MEMBER WALLIS: Has this been through a subcommittee?

MEMBER SIEBER: No.

MEMBER WALLIS: That is why we are getting all this --

MEMBER SIEBER: yes this is cold.

MEMBER WALLIS: EMI is electromagnetic interference?

DR. WOOD: Yes.

MEMBER WALLIS: So it is a separate guide from this one?

DR. WOOD: yes.

MEMBER POWERS: It has been before the committee since you have been on the committee.

DR. KORSAH: That Reg Guide 1.180 deals

specifically with EMI. This reg guide deals with all aspects of the environment; high temperature, humidity, EMI, and those kinds of things.

MEMBER WALLIS: So it deals with all of them?

DR. KORSAH: All of them, yes.

MEMBER POWERS: It was in fact one of our complaints about the EMI/RFI was that the reg guide didn't address all of the stressors.

DR. WOOD: We tried to listen.

MEMBER POWERS: Darn it. You are not supposed to do that.

DR. WOOD: I apologize. How do those location categories show up as positions and there were a lot of comments because it was I think not well presented in the original version, and we think that it is now.

And to make it clearer what is the intent, and the intent is not to go out and map every plant. The intent is to identify some locations that everyone can agree are harsh, and everyone can agree don't have aging mechanisms.

So that you don't have to go through an assessment. So Category A, which are the 10 CFR 50.49 kind of categories, the so-called harsh environments subject to design-basis accidents, aging must be addressed, and the conditions and clarifications, and exceptions, however you want to call them, that are in Reg Guide 1.189, are incorporated within DG-1077 by reference.

For a microprocessor-based system, you can use IEEE 323, or you can use IEC 6780. That is for Category A. For Category C, and I will jump down a little bit, aging does not need to be addressed and so it can be omitted from the test sequence if type testing is used, and there does not have to be any documentation of the age conditioning or the assessment of age conditioning.

Category B, which of course is equivalent to what had to be done for model environments in any event, you have to assess whether there is a significant aging mechanism.

You either include your aging condition if there are as part of your documentation, or you can include the findings of your assessment, saying that there aren't significant aging mechanisms. So I think it is pretty clear, I hope.

And then the final -- I will get this right probably after the presentation is over, and I apologize. The final position deals with margin, and the purpose for this position being there is that there is one suggested margin factor in IEEE 323 that is not included in IEC 6780, and so it is just identified that if you are using IEC 6780, consider this as one of the suggested margin factors.

So that is basically the position, and now to try to be brief about it, four positions were deleted from what went out for public comment, because we agreed with the substance of the comment. Maybe not the details, but certainly that this could constitute an expansion of what has traditionally be called environmental qualification.

One dealt with standards and test practices used by the integrated circuit manufacturers can be identified and listed for each supplier to ensure the use of quality components.

And that is basically to say that it is fine to say that this type is representative of this entire product line, but what if there is a change in the supplier of this integrated circuit.

How do you know that is the same quality as the one that you tested. In Japan, Hitachi performs these kinds of tests on every chip that is sent to them that is going into their nuclear power plant product line.

But still an electromigration issue occurred at Akashiwasaki wae-ri wae (phonetic), but that was from a much earlier version. This was Position 8 in what was released for public comment. The intention was not that the licensee perform these tests, or that the vendor perform these tests.

The intention was that you just document that these kinds of tests were performed for every component product line that you use.

MEMBER FORD: But you do know how to relate those standardized tests to the variation in all the temperatures, and radiation, and sulfide, and all those wonderful range of things that you could have in a reactor.

These are good for, as you said, for Hitachi to come out and say hey, and put a stamp on it, but it has not relation at all, risk-based, or-risk informed, or otherwise, for how long it is going to last in the reactor.

DR. WOOD: The only relation that we were intending to promote is that this indicates that you are using a qualify product, and that it has been demonstrated to be capable of surviving in the kinds of =-=

MEMBER FORD: Yes, but you can say a Rolls Royce is a great product, but it won't last in the Sahara.

DR. WOOD: Your arguments and the arguments of the public comments were well taken, and that is why this position was taken.

MEMBER FORD: So why is it taken out? I thought that this document that you formulated is an umbrella document?

DR. WOOD: It is.

MEMBER FORD: So why then take out the most important part?

DR. WOOD: Well, what we have taken out here is the umbrella information for environmental compatibility. We have the road map for -- what remains is the road map for environmental qualification. The things that were taken out dealt with quality, and design, and implementation, which are not direct elements of environmental qualification.

Environmental qualification by definition is verification of your design, that your design can accommodate its environment. So these other things dealt with building quality in and using designs that minimize the -- I guess what kinds of environments it might be exposed to.

MEMBER FORD: So how would you deal with, for instance, an ACR-700? It would seem to be certified and you are judging whether that should be used, qualified, and do you just go on to Hitachi microprocessors and say, hey, pass their rests, and therefore it is okay?

DR. WOOD: No, this was not intended to be I guess a free pass beyond the qualification process of your system, or your piece of equipment. This was just some supplemental information that could confirm that if you have done type testing that that type is in fact representative of every incarnation of that system that is going to be placed in your plant.

If you buy a replacement, an exact replacement two years from now, and you have gotten that from a different vendor.

MEMBER FORD: Then how do you relate that entire past design to how it will behave in the reactor specifically then?

DR. WOOD: You do it through environmental qualification, and subjecting it to the kinds of environments that are --

MEMBER FORD: Okay. Then this is just

to make sure that every item that you get is the same?

DR. WOOD: Right.

MEMBER SIEBER: Well, one of the problems there is that a lot of this stuff I think ius going to be commercial off-the-shelf, which means that the manufacturer and the chip maker, which is usually two different folks, can change whatever they want at any time that they want and call it an improved model, or don't call it anything, and you don't know whether that device is qualified or not, except for the piece of paper that you get with it.

DR. WOOD: That is going to happen, and at least looking at it, the way to address it is part of quality control, but you are right. Two years from now the next commercial product, or the next instance of that commercial product may not be the same as the one that was dedicated.

So those are tricky things that are additional burdens for the staff.

MEMBER SIEBER: Well, I think that the standard is weak when addressing that, you know. You don't have requirements that say, well, you had better analyze to make sure that the chips are the same, and the motherboards are the same, and the cabinet is the same, and the connections are the same. The other components that fit in there are the same.

DR. WOOD: It says those things except for make sure that the chips are the same.

DR. KORSAH: And I think in addition to that, and to be fair, most IC manufacturers actually do have a lot of stress screening tests for quality control.

MEMBER SIEBER: That's true, but those tests are not specifically designed for harsh environments. They are designed to make sure that they can product a high quality chip or the $200 or $300 that they charge for them.

DR. KORSAH: But one of the reasons why we listen to the public comments in this particular issue is that in fact when we looked at the actual stress screening test that they do, and many of the temperatures and humidities are compatible with the design of the design basis accidents that you might see. So that is why we listen to the public comments also.

MEMBER WALLIS: I think the interesting thing here is that you have got an industry which is mature and has regulations, and is an industry developed very slowly, and there have been very significant changes in the design of a PWR/BWR regulations, and it doesn't matter if they have a response time of 5 or 10 years.

Now you have got an industry with microprocessors and chips which is developing all the time, and things change year, by year, by year., by year. And it is just interesting to see if this agency can respond to that kind of technology predicted into this very slow moving technology.

DR. WOOD: Those of us in the instrumentation and control field have always chuckled a little bit whenever obsolescence is brought up because obsolescence in the digital world takes on a completely different meaning and pace.

But we felt like there was value to this position,b ut we agreed with the public comments that this position complicated this guidance, and so it was deleted. The information still exists.

And basically the same thing here for multi-tiered protection. The motivation behind putting it there to begin with was to address things like smoke.

This was really the only way that we

could take the findings of the research project, and have an impact. And it was not a requirement that you do things in a particular way. It was a suggestion that you document the different things that you do that can minimize your potential vulnerability to environmental conditions.

But again it was perceived an additional burden, and we acknowledge that this deals with the bigger score of environmental compatibility, versus environmental qualification.

So this was deleted in the revised draft guide, but the information still is maintained in the accompanying NEUREGs. And then the final two, and basically the first one about identifying life-limited components.

It was a bit of, well, if we are not doing a qualified life, how do you know that you can't leave it, and how do you realize that they can't leave it there for 60 years.

But then the public comments caused us to think about it a little bit, and we looked in a little more detail at the standard, and that is explicitly stated as one of the bits of information that you collate about your product.

So it was in this case redundant with

what was being endorsed, and so it was deleted.

MEMBER WALLIS: The problem with rapidly developing technology like this is that by the time that you have done enough to find out what the operational life of something is, you can't even buy it anymore because it has developed into several others.

DR. WOOD: Well, you would like for your I&C system to be good for about 15 years, and then the last one had to do with on-line surveillance, and there are surveillance -- some surveillance guidance in Reg Guide 1.189 for harsh environments, where you can't access your equipment, and we agreed with the public comments that this was not necessary in this guide, because it also addressed some issues that dealt with design.

So that position was deleted. So what we feel is that we have got a fairly straightforward reg guide, and that is perfectly consistent with the practices, but it can eliminate the need for each vendor submitting their program and an individual evaluation of that program.

And now I will rest my voice and also your ears and let the lovely Ms. Antonescu serenade you with the conclusions.

MEMBER SIEBER: I have a question to ask before you jump ahead.

DR. WOOD: Okay.

MEMBER SIEBER: I presume that things like fiberoptics are not covered under any of these standards because they are not electric other than the sending and receiving end of it.

So what do you do about qualification, environmental qualification and things like fiberoptics?

DR. WOOD: There is a reg guide and there is a standard, IEEE Standard 383, that addresses cables and there is a significant research program looking at --

MEMBER SIEBER: I am aware of the research program.

DR. WOOD: Exactly.

MEMBER SIEBER: But the standard I thought addressed metallic?

DR. WOOD: It does. It does not address optical cables.

MS. ANTONESCU: But I think in one of the future revisions it will address fiberoptic cable.

DR. WOOD: For what is going to be

balloted this year throughout IEEE, it will not, but for the next revision, I think they have plans to take that up.

But you are talking about maybe 5 years before that happens, and one of the public comments suggested somebody needs to look at optic cables.

MEMBER SIEBER: It seems that somebody could jump in right now and decide to install it, and the staff would be running around like chickens with their heads cut off trying to figure out what do I do now, because it doesn't fit anything.

DR. WOOD: Right. The design that I showed of the ABWR uses optical fiber networks.

DR. WOOD: And military applications are strong on that, too, because it eliminates the radio frequency interference, and all that kind of stuff.

DR. WOOD: But the cables themselves are covered in another reg guide, and are beyond the scope of both Reg Guide 1.189, I believe, and I can't say that for sure, but definitely DG-1077.

MEMBER SIEBER: They aren't in here, and they are not in any other place that I am aware of.

DR. WOOD: Okay.

MR. BESSETTE: Just additional knowledge, but you are aware of the aging research programs, and things like that. But there is also a small research program done about 5 years ago for looking at qualification issues associated with fiberoptics.

MEMBER SIEBER: I am aware of that.

MR. BESSETTE: Okay.

MEMBER SIEBER: But that is not a regulation.

MR. BESSETTE: No, it is not, but we have some information that if we chose to do a fast track regulatory position.

MEMBER SIEBER: Well, I could see this becoming an issue, because maybe you don't have fiberoptics thrown all over containment, but you have got optical isolators, and things like that which are just little tiny sections of fiber that are embedded in a chip, and so the issues are there.

And it seems to me that they are affected by radiation in a more significant way than metallic conductors are.

DR. WOOD: I know that there has been a lot of research that has been conducted, and I recall from some discussions at one of those DOE meetings that we had trying to bring I&C experts together. And a particular individual telling me that the optical cables susceptibility to radiation was perhaps misstated.

Yes, it does have an effect in the visible frequency ranges, but it is perfectly okay in some of the other frequency ranges.

MEMBER SIEBER: And it become opaque and it also become brittle.

DR. WOOD: Yes, that's true.

CHAIRMAN BONACA: We are running out of time.

DR. WOOD: Okay.

MS. ANTONESCU: So I would like to wrap up by going over again the benefits of this reg guide. It does give explicit guidance on acceptable methods for environmental qualification of safety related microprocessor-based equipment.

It provides a comprehensive guidance since the guidance that we have right now is distributed all over several sources as Mr. Wood said on Reg Guide 1.189, and NEUREG 0588, and (inaudible) Chapter 7 and Chapter 3.

And also it provides endorsement of the current national and international standards, consensus standards. And it does include specific guidance to address unique characteristics of microprocessor-based technology.

And finally to it supports a streamlined approach to the initial determination of whether aging is necessary. And specifically by designating plant location that clearly do not require aging, and you have seen Dr. Wood's presentation and that category.

So your public comments provide clarify and a sharper focus on this reg guide, and in particular the public comment showed widespread support for endorsement of the current standards, and many of the comments were a result of a misunderstanding of the intent and application of the reg guide, and so we improved it.

The regulatory discussion and position were expanded and we improved on them. So this provided more clarity.

MEMBER FORD: What is your basis for saying that? Do you have widespread agreement with this? Have they come back for a second time around to look at your revised documents? What is your basis for saying --

DR. WOOD: What she is saying is support for the endorsement of the current standards, and that is not the same as support for the draft guide.

MS. ANTONESCU: For the consensus standards.

DR. WOOD: They recommended that other venues be used to endorse the standards.

MS. ANTONESCU: And so we have public comment open for revision, and scope and purpose, and we did clarify those, and finally we found some positions that Dr. Wood mentioned that were completely deleted because there was supplemental information supporting the environmental compatibility, but not directly to an environmental qualification.

And those were -- some of them were like the I&C manufacturing and testing. And overall it supports the NRC mission, and it contributes to achieving NRC goals, and helps maintain safety by providing an approach for verifying the environmental stress, and it does not hinder performance.

It gives a definitive explicit guide on acceptable practices, and it reduces its regulatory burden by minimizing potential regulatory uncertainty, and streamlining the determination of necessary qualification steps, and that is the example of when aging is necessary.

And it improves the regulatory effectiveness by giving explicit guidance on acceptable practices, for environmental qualification, and addresses unique characteristics.

So we do thank you for the opportunity to present this guide to you today, and we look forward to a letter with your comments on this draft reg guide.

MEMBER WALLIS: If I go back and read the Winston and Strawn comments, they are exactly the opposite of yours. They are saying that it is unnecessary and unwarranted, and have no effect on safety, and it doesn't part from minimizing the uncertainty, and it creates confusion and instability in the process.

MS. ANTONESCU: I'm sorry, which --

MEMBER WALLIS: I am reading their letter here I don't understand how to reconcile these positions.

MS. ANTONESCU: Well, we have a viewgraph on --

MEMBER WALLIS: Have you established that there is a reconciliation of their views in some way?

MS. ANTONESCU: We have reconciled, yes.

MEMBER WALLIS: You have reconciled? With these extremely different views, you have reconciled? You think you have reconciled?

DR. WOOD: What we believe is that the disagreements over the need for this guidance were based on a misunderstanding of the guidance, and we went through great pains to try to be much more systematic in the discussion that led into the regulatory position, and we deleted positions within the regulatory position that we agree could have led to complications and uncertainty, and additional burden.

MEMBER WALLIS: Maybe it would be appropriate to ask the representative from Winston & Strawn saying that now that I have heard this, do they agree.

MEMBER SIEBER: Well, whether they have heard it or not, to be able to give an opinion one way or the other, because they have not given them word by word changes.

CHAIRMAN BONACA: yes.

MEMBER SIEBER: And had they given them the justification for the comments, as they had about --

MEMBER WALLIS: What are we supposed to

do? We are not going to write a letter are we? I don't have a basis for deciding either. This has not been seen by the people who were very critical of the previous views, and so I really don't know what to say.

MEMBER SIEBER: Perhaps we can provide the members with a copy of the public comments and resolution that you gave me.

MR. HORIN: If I may, I might suggest that I think consistent with previous practice and first off, I do want to express appreciation for your efforts to address the comments, and I recognize that there has been a lot of effort and thought in that respect.

But again the devil is in the details as they say, and we have not seen what the end result is. So we would appreciate an opportunity to be able to review what the proposed changes are, and have an opportunity to interact in some fashion in that regard.

It may even be appropriate at some point whether the subcommittee or this committee might want an opportunity to look at that next generation with an opportunity already having been provided for additional review.

MEMBER SIEBER: Well, that goes beyond what the regulations require for the issuance of a regulatory guide. You know, you don't keep on going, and going, and going.

DR. WOOD: I will note that I did have or I did attend the working group meeting, and I am now a member of the working group for the IEEE on IEEE 323, the revision of IEEE 323.

And I did engage in discussions with the group that is writing the revision of that standard, and I have had a lot of discussions with our international colleagues as well, and I have had discussions with a variety of members of the industry stakeholders.

I think that the guidance itself, the major objections as you indicated, had to do with whether or not this was expanding the scope of 10 CFR 50.49. I hope that we have illustrated that that is not the case.

The other had to do with defining the EMI/RFI as an aging stressor.

CHAIRMAN BONACA: Right.

DR. WOOD: And I hope that we have also indicated that we didn't do that, but we are moving into agreement with the international position that it is an environmental condition.

While that large document that you have with the response to the public comments, there were 115 comments, and a little less than half of those were just repetitive. The majority of them dealt with the need for this guide.

And is the existing guidance sufficient, and is this guide consistent, and is this guide confusing, and is there a need for something for a microprocessor-based versus analog.

We think that we have addressed those things by clarifying the discussion. The issue of the location categories, we think we also addressed by clarifying how do you use them, and trying to make their application a lot more practical.

The issue of the scope of qualification is a matter of understanding what qualification is, and I could give you another two hours on qualifications, but I won't do that.

CHAIRMAN BONACA: The only concern that I have about writing a report on this at this stage is that in part it is true that the devil is in the details, and you are still in the process of communicating with industry.

And we intentionally waited until the

comments were resolved. I mean, I think --

MEMBER SIEBER: Well, maybe I could address that. One of the problems that I think we had in our procedure was that there was no subcommittee meeting. In fact, there is no I&C subcommittee that I am aware of.

And so we came into this cold and the documents that I now have, or the ones that or some of which I had to ask for, because I knew they were generally produced during the course of staff's doing their business.

And I have had the opportunity now to ask for them, and received them, and study them, which gives me an advantage over everybody else, and that's probably why I tend to be a little flip with my responses, for which I apologize.

On the other hand, if I were in other committee members' shoes, I would say I certainly have not been provided with enough information to make this decision.

And I don't know that we can provide the documents, and I think in the aggregate that the documents do answer the questions. On the other hand, it is a pretty good sized stack for overnight reading.

MEMBER SIEBER: Well, I think we should end the meeting, and then when we talk about the reports, then we will discuss it at that time and see what -- because I mean that there are things that can be said, and so why don't we do that.

MEMBER SIEBER: I think that would be a good idea. So I will turn it back to you.

CHAIRMAN BONACA: Okay.

MEMBER SIEBER: But I would like to thank our speakers today for good presentations, and good preparation for the discussion, and representatives from Winston & Strawn for coming here and giving us the views of the Nuclear Utility Group on Equipment Qualification. So with that, I will turn it back to you, Mr. Chairman.

CHAIRMAN BONACA: Thank you. With that, I thank you very much, and we will take a recess until 5:15, and at this point, we will not need the recorder anymore. So, at 5:15, we will just talk about these reports and see what we have, and what our plans are.

(Whereupon, the hearing was concluded at approximately 5:01 p.m.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards 499th Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Rebecca Davis

Rebecca Davis
Official Reporter
Neal R. Gross & Co., Inc.

Duke Energy®

McGuire – Catawba License Renewal

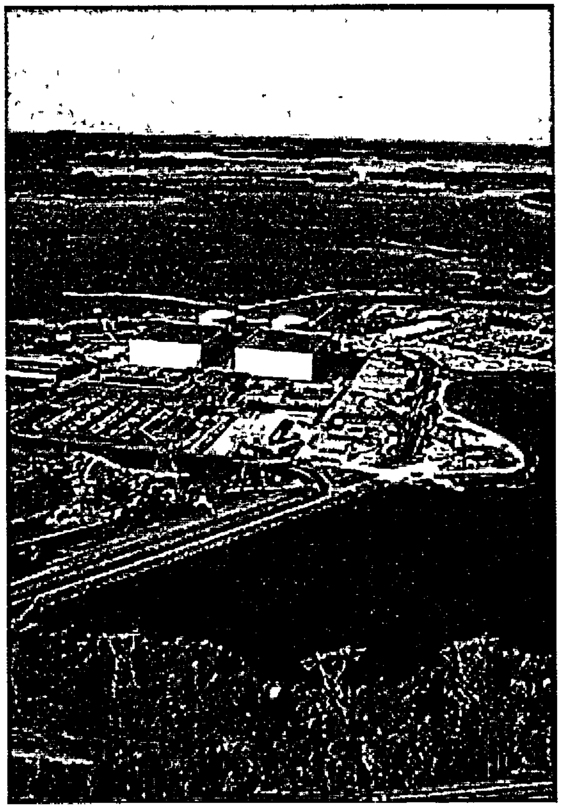
Presentation
To
Advisory Committee on
Reactor Safeguards

McGuire

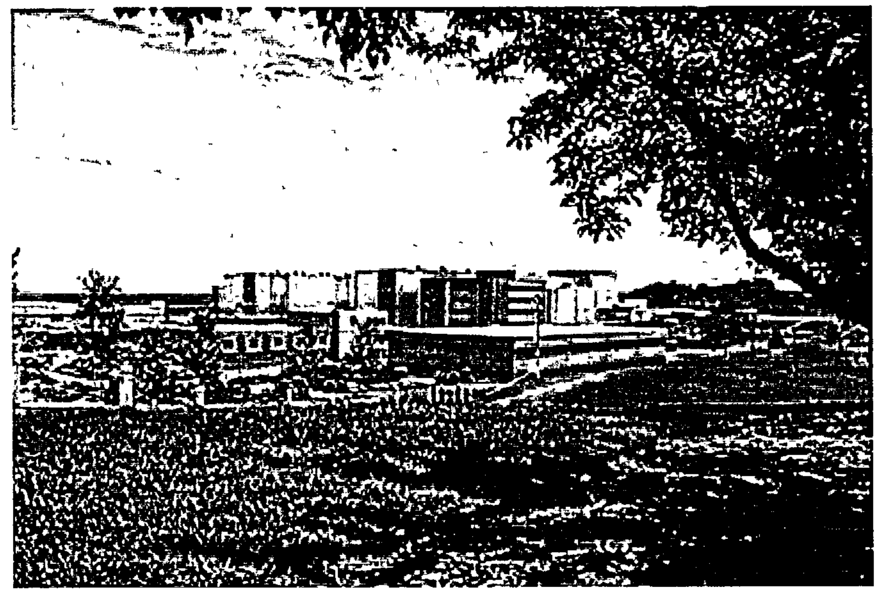
Catawba

Robert L. Gill, PE
Gregory D. Robison, PE

February 6, 2003



McGuire Nuclear Station
Huntersville, North Carolina



Catawba Nuclear Station
York, South Carolina

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Plant Description

McGuire

- McGuire Nuclear Station is a 2 Unit Site - 2258 MW total
- Construction finished in early 1980's
- Initial capital cost was approximately $1100/kW
- Commercial operation began
  - 1981 - Unit 1
  - 1984 - Unit 2
- Initial licenses expire in 2021 and 2023
- About 1100 people are employed at McGuire

Catawba

- Catawba Nuclear Station is a 2 Unit Site - 2258 MW total
- Construction finished in early 1980's
- Initial capital cost was approximately $1500/kW
- Commercial operation began
  - 1985 - Unit 1
  - 1986 - Unit 2
- Initial licenses expire in 2024 and 2026
- About 1100 people are employed at Catawba

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Agenda

- Application Background
- Duke Responsibilities Going Forward

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Application Background

- NRC approved Duke's exemption request from the 20 year requirement of 10 CFR 54.17(c)
  - ➢ Expiration dates of each renewed license will be unit specific
    - 20 years from expiration of current license or 40 years from date of issuance of the renewed operating license, whichever is earlier

- June 2001 - Application submittal
- December 2002 - Site Supplemental Environmental Impact Statements issued
- January 2003 - Safety Evaluation Report issued
- Safety and environmental reviews cover 60-years

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Duke Responsibilities Going Forward

- Implement UFSAR Supplement when the next UFSAR update occurs
- Complete aging management program and activity commitments as described in UFSAR Chapter 18, *Aging Management Programs and Activities*
  - Existing
  - Enhancements to existing
  - New programs, inspections and activities
- Evaluate plant changes to assure that the commitments are maintained
- Maintain records to support future assessment and inspection requirements

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Implementing Commitments

- Plant-specific turnover specification (Spec 0016) identifies detailed changes required for existing plant documents:
  - Procedures
  - Work Orders
  - Hardware Aging Management Programs
  - Engineering Support Programs
- Implementation Monitoring Plans for Future Inspections and Activities

4.42 Pressurizer Spray Head Examination

References:

UFSAR / TS Section:	UFSAR Section 18.2.20
Safety Evaluation Report Section:	Section 3.1.2.2.2
Application Section:	None [Response to RAI 2.3.2.7-1, April 15, 2002]
Basis Specifications:	DPS-1274.00-00-0005
Other:	Duke letter 10/28/02 (O.I. 3.1.2.2.2-1)

The *Pressurizer Spray Head Examination* is credited in Duke's response to RAI 2.3.2.7-1 in support of the McGuire and Catawba license renewal application (LRA) as a one-time inspection that will provide insights to better characterize potential aging that may be occurring in the pressurizer spray heads. The applicable aging effect is cracking due to reduction of fracture toughness (due to thermal embrittlement). The examination will consist initially of a visual (VT-3) inspection of one spray head in the McGuire Unit 1 pressurizer, with possible subsequent inspections of pressurizer spray heads at McGuire Unit 2 and Catawba Units 1 and 2.

The committed attributes of the *Pressurizer Spray Head Examination* are discussed in Section 18.2.20 of the McGuire UFSAR. More details for the basis and the determination of the adequacy of the program are documented in specification DPS-1274.00-00-0005, *License Renewal Aging Management Programs and Activities.*

The following milestone items are part of the implementation monitoring plan to manage the commitments of the *Pressurizer Spray Head Examination* as described in the UFSAR. These items are being monitored by Regulatory Compliance for timely completion. Slippage of these activities should be reviewed for impact with the owning organization and re-scheduled such that the commitments can still be tracked and completed within the required time.

Task Description	Complete By:
☐ Create procedure(s) as necessary to implement the visual inspection requirements based on VT-1 methodology and acceptance criteria.	12/31/17
☐ Perform the spray head examination on Unit 1.	6/12/18
☐ Based on the results of the Unit 1 examination, evaluate the need for Unit 2 examination, or for additional Unit 1 examinations.	12/31/18
☐ Perform the spray head examination on Unit 2, if necessary.	3/3/19
☐ Develop programmatic oversight for the period of extended operation, if necessary.	6/12/20

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Commitment Management

- The commitments made for license renewal must be maintained pursuant to 10 CFR 54.37(b)
- Changes to the UFSAR commitments can be made via the existing 50.59 process

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Evaluating Plant Changes

Plant changes that can impact renewal commitments

- Physical plant modifications
- Operational changes
- Current licensing basis changes, via bulletins, generic letters, regulations, orders, etc.

Key: Site engineering is involved in these plant changes

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Evaluating Plant Changes

- Engineering Oversight Document (EDM 229)
  - Process for maintaining license renewal scope and aging management of components within license renewal scope
  - Defines specific responsibilities, including establishing an Aging Management Site Point of Contact (SPOC)
  - Provides a method to perform Aging Management Reviews should they be required

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Evaluating Plant Changes

- Aging Management SPOC Duties
  - Site Technical Point of Contact
  - Can provide guidance for Aging Management Reviews
  - UFSAR Chapter 18 overall Site Owner (Individual program owners own their pieces)
  - Independent check of UFSAR Chapter 18 program changes

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Evaluating Plant Changes

- License Renewal Handbook (Spec 0017)
  - Developed to aid the Aging Management SPOCs in evaluating the impact of plant changes on license renewal programs and scope
  - Contains license renewal scope definition, smart charts, implementation plans, and drawings
  - Updated as necessary to reflect future plant changes

APPENDIX A – MCGUIRE AGING MANAGEMENT REVIEW SMART CHART

Auxiliary Feedwater System (CA)

McGuire System	Material (2)	Environment	Aging Management Program	Aging Effect	Aging Mechanism	Component Type	Function (1)
Auxiliary Feedwater System (CA)	Carbon Steel	Reactor Bldg	Fluid Leak Management Program	Loss of Material	Boric Acid Wastage	pipe	PB
			Inspection Program for Civil Engineering Structures and Components	Loss of Material	General Corrosion		
		Sheltered	Fluid Leak Management Program	Loss of Material	Boric Acid Wastage	pipe, valve bodies CA Motor-Driven Pump (casing) CA Turbine-Driven Pump (casing)	PB
			Inspection Program for Civil Engineering Structures and Components	Loss of Material	General Corrosion		
		Treated Water	Chemistry Control Program	Loss of Material	Crevice Corrosion Galvanic Corrosion General Corrosion Pitting Corrosion		
Auxiliary Feedwater System (CA)	Stainless Steel	Lubricating Oil	None Required	None Identified	None Identified	CA Turbine-Driven Pump Bearing Oil Cooler (tubes)	PB, HT
						tubing CA Turbine-Driven Pump Bearing Oil Cooler (shell-side, tubesheet)	PB
		Sheltered	None Required	None Identified	None Identified	orifices	PB, TH
						pipe, tubing, valve bodies CA Turbine-Driven Pump Bearing Oil Cooler (end caps, shell-side)	PB
		Treated Water	Chemistry Control Program	Fouling	Silting	CA Turbine-Driven Pump Bearing Oil Cooler (tubes)	PB, HT
				Cracking	Stress Corrosion		
				Loss of Material	Crevice Corrosion Pitting Corrosion		
				Cracking	Stress Corrosion	orifices	PB, TH
				Loss of Material	Crevice Corrosion Pitting Corrosion	pipe, tubing, valve bodies CA Turbine-Driven Pump Bearing Oil Cooler (end caps, tubesheet)	PB
				Cracking	Intergranular Attack	Valves 1CA0057 and 1CA0045 (bodies)	PB

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Maintaining Records

- The Duke license renewal implementation process assures that documents, plans, procedures, communication and coordination are in place to effectively manage the renewal commitments
- Future Duke assessments and NRC inspections will serve to validate commitment management (e.g. draft NRC Inspection Procedure 71003 issued 12/09/02)

McGuire and Catawba License Renewal SER

Staff Presentation to the ACRS
Rani Franovich, Project Manager
February 6, 2003

Agenda

- Opening Remarks . ... M Bonaca
- Staff Introduction . .. . P.T Kuo
- Application Overview. .. . . . G Robison
- Safety Evaluation Report . . R Franovich
- Status of Legal Proceedings .. R Franovich

Chapter 2: Scoping and Screening

- Three open items (applied to auxiliary systems)
  - Fan housings
  - Damper housings
  - Building sealants (structures issue)

Chapter 2: Scoping and Screening (continued)

- Two open items in fire protection scoping and screening
  - Jockey pumps
  - Manual suppression in potential fire exposure areas

Chapter 3: Aging Management Review (AMR) Results

- Section 3.0, Common AMPs
  - ISI-Volumetric examination of Class-1 small-bore pipe
- Section 3.3, Auxiliary Systems
  - Condenser circulating water system no aging effects specified for rubber expansion joint in yard

Chapter 3: AMR Results (continued)

- SER Section 3.5, Structures
  - Aging of concrete structures
  - Aging management for inaccessible concrete ice condenser structural components

Chapter 3: AMR Results (continued)

- Section 3 6, Electrical and Instrumentation and Controls
  - Open item pertaining to aging management of sensitive, high-range radiation and neutron monitoring instrumentation cables to monitor insulation resistance

Status of Legal Proceeding

- Intervenors
  - Blue Ridge Environmental Defense League
  - Nuclear Information & Resource Service
- Contention
  - Severe Accident Mitigation Analysis for SBO
- Recent Actions
  - Commission Order
  - Duke request for dismissal

OMB Control No.: 3150-0011

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555

(Date to be issued for comment)

NRC GENERIC LETTER 2003-XX: POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN-BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS

Addressees

All holders of operating licenses for pressurized-water nuclear power reactors, except those who have ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this generic letter to:

(1) Apprise addressees of the results of NRC-sponsored research identifying the potential susceptibility of pressurized-water reactor (PWR) recirculation sump screens to debris blockage during design-basis accidents requiring recirculation operation of the emergency core cooling system (ECCS) or containment spray system (CSS).

(2) Apprise addressees of the potential for additional adverse effects due to debris blockage of ECCS recirculation and containment drainage flowpaths.

(3) Request that addressees ~~take the appropriate~~perform an evaluation of the ECCS and CSS recirculation functions in light of the information provided, and, if appropriate, take the additional actions described in this letter to ensure their reliability~~ of ECCS and CSS recirculation~~.

(4) Require addressees to inform the NRC of the extent to which they will take the requested actions.

Background

In 1979, as a result of evolving staff concerns related to the adequacy of PWR recirculation sump designs, the NRC opened Unresolved Safety Issue (USI) A-43, "Containment Emergency Sump Performance." To support the resolution of USI A-43, the NRC undertook an extensive research program, the technical findings of which are summarized in NUREG-0897, "Containment Emergency Sump Performance," dated October 1985. The resolution of USI A-43 was subsequently documented in Generic Letter (GL) 85-22, "Potential for Loss of

Post-LOCA Recirculation Capability Due to Insulation Debris Blockage," dated December 3, 1985. Although the staff's regulatory analysis concerning USI A-43 did not support imposing new sump performance requirements upon licensees of operating PWRs or boiling-water reactors (BWRs), the staff recommended in GL 85-22 that all reactor licensees replace the non-conservative 50%-blockage assumption (with which most nuclear power plants had been licensed) with a comprehensive, mechanistic assessment of plant-specific debris blockage potential for future modifications related to sump performance, such as thermal insulation change-outs. The staff also updated the NRC's regulatory guidance, including Section 6.2.2 of the Standard Review Plan (NUREG-0800) and Regulatory Guide 1.82, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," to reflect the USI A-43 technical findings documented in NUREG-0897.

Following the resolution of USI A-43 in 1985, several events occurred that challenged the conclusion that no new requirements were necessary to prevent the clogging of ECCS strainers at operating BWRs:

- On July 28, 1992, at Barsebäck Unit 2, a Swedish BWR, the spurious opening of a pilot-operated relief valve led to the plugging of two containment vessel spray system suction strainers with mineral wool and required operators to shut down the spray pumps and backflush the strainers.

- In 1993, at Perry Unit 1, two events occurred during which ECCS strainers became plugged with debris. On January 16, ECCS strainers were plugged with suppression pool particulate matter, and on April 14, an ECCS strainer was plugged with glass fiber from ventilation filters that had fallen into the suppression pool. On both occasions, the plugged ECCS strainers were deformed by excessive differential pressure created by the debris plugging.

- On September 11, 1995, at Limerick Unit 1, following a manual scram due to a stuck-open safety/relief valve, operators observed fluctuating flow and pump motor current on the "A" loop of suppression pool cooling. The licensee later attributed these indications to a thin mat of fiber and sludge, which had accumulated on the suction strainer.

In response to these ECCS suction strainer plugging events, the NRC issued a number of generic communications, including Bulletin 95-02, "Unexpected Clogging of a Residual Heat Removal (RHR) Pump Strainer While Operating in Suppression Pool Cooling Mode," dated October 17, 1995, and Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors," dated May 6, 1996. These bulletins requested that BWR licensees implement appropriate procedural measures, maintenance practices, and plant modifications to minimize the potential for the clogging of ECCS suction strainers by debris accumulation following a loss-of-coolant accident (LOCA). The NRC staff has concluded that all BWR licensees have sufficiently addressed these bulletins.

However, recent findings from research to resolve the BWR strainer clogging issue have raised questions concerning the adequacy of PWR sump designs. In comparison to the technical findings of the USI A-43 research program concerning PWRs, the new research findings demonstrate that the amount of debris generated by a high-energy line break (HELB) could be greater, that the debris could be finer (and, thus, more easily transportable), and that certain combinations of debris (e.g., fibrous material plus particulate material) could result in a substantially greater head-loss than either type of debris alone. These new research findings prompted the NRC to open Generic Safety Issue (GSI) 191, "Assessment of Debris Accumulation on PWR Sump Performance." The objective of GSI-191 is to ensure that the accumulation of debris in PWR containments would not impede or prevent the recirculation functions of the ECCS and CSS pumps during LOCAs or other HELB accidents for which recirculation is required.

Debris blockage at flow restrictions within the ECCS recirculation flowpath downstream of the sump screen is a related technical issue which may also affect addressees of this generic letter. For debris blockage to occur at flow restrictions downstream of the sump screen, such as a high-pressure safety injection (HPSI) throttle valve or fuel assembly inlet debris screen, pieces of debris would need to have spatial dimensions that would allow them to pass through the sump screen openings, yet become lodged at downstream flow restrictions within the ECCS recirculation flowpath. In particular, conditions favorable to downstream debris blockage may exist at PWRs for which the maximum dimension of the sump screen openings (e.g., the diagonal dimension of a rectangular screen) does not constitute the most-restrictive point in the ECCS recirculation flowpath. Debris blockage at flow restrictions in the ECCS flowpath downstream of the sump screen could impede or prevent the recirculation of coolant to the reactor core, thereby leading to inadequate core cooling. Similarly, debris blockage at flow restrictions in the CSS flowpath downstream of the sump screen could impede or prevent the recirculation mode of the CSS, thereby leading to inadequate containment heat removal.

The NRC alerted PWR licensees to this potential concern by issuing Information Notice (IN) 96-27, "Potential Clogging of High Pressure Safety Injection Throttle Valves During Recirculation." IN 96-27 discusses the HPSI throttle valve clogging susceptibility determinations performed by the licensees for the Millstone Unit 3 and Diablo Canyon nuclear power plants. The susceptibility determinations performed by these licensees concluded that HPSI throttle valve clogging was not credible on the basis of plant-specific features, such as the capability of HPSI pumps to pulverize debris, the high differential pressure across the HPSI throttle valve opening, and the settling of certain types of debris upstream of the sump screen. However, when the licensee for the Byron and Braidwood nuclear power plants subsequently performed a similar susceptibility determination, the NRC staff identified concerns regarding the types of debris the licensee had considered, the size range and transportability of these types of debris, and the uncertainties concerning the capability of HPSI pumps to pulverize these types of debris significantly. The staff's review concluded that an insufficient experimental or analytical basis exists to validate a number of assumptions that licensees have generally used to demonstrate the incredibility of HPSI throttle valve clogging. Currently, the NRC staff is developing screening criteria for assessing the susceptibility of operating PWRs to HPSI throttle valve clogging and investigating whether further research is necessary to support the resolution of this potential concern. The objective of the NRC's efforts is to ensure that the accumulation of debris at HPSI throttle valves would not prevent the recirculation function of the ECCS from mitigating design-basis accidents for which it is required.

<u>Discussion</u>

In the event of a HELB inside the containment of a PWR, energetic pressure waves and fluid jets would impinge upon materials in the vicinity of the break, such as thermal insulation, coatings, and concrete, causing them to become damaged and dislodged. Debris could also be generated through secondary mechanisms, such as severe post-accident temperature and humidity conditions, flooding of the lower containment, and the impact of containment spray droplets. Through transport methods such as entrainment in the steam/water flows issuing from the break and containment spray washdown, a fraction of the generated debris and sources of foreign material in the containment would be transported to the pool of water formed on the containment floor. Subsequently, if the ECCS or CSS pumps were to take suction from the recirculation sump, the debris suspended in the containment pool would begin to accumulate on the sump screen. The accumulation of this suspended debris on the sump screen would create a roughly uniform covering on the screen, referred to as a debris bed, which would tend to increase the head-loss across the screen through a filtering action. If a sufficient amount of debris were to accumulate, the debris bed would reach a critical thickness at which the head-loss across it would exceed the NPSH margin required to ensure the successful recirculation functions of the ECCS and CSS pumps. A loss of NPSH margin for the ECCS or CSS pumps as a result of the accumulation of debris on the recirculation sump screen, referred to as sump clogging, could result in degraded pump performance and eventual pump failure.

To determine whether the ECCS and CSS pumps at domestic PWRs are susceptible to a loss of NPSH margin during sump recirculation, the NRC sponsored a GSI-191 research program, which culminated in a parametric study that modeled each PWR plant using a combination of generic and plant-specific data. As documented in Volume 1 of NUREG/CR-6762, "GSI-191 Technical Assessment: Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance," dated August 2002, the GSI-191 parametric study concluded that recirculation sump clogging is a credible concern for the population of domestic PWRs. The parametric study's conclusion is ultimately based upon the substantial body of test data and analysis that is documented in technical reports generated during the NRC's GSI-191 research program and earlier technical reports generated by the NRC and the industry during the resolution of the BWR strainer clogging issue and USI A-43. These pertinent technical reports are incorporated by reference into the GSI-191 parametric study (NUREG/CR-6762, Volume 1). On the basis of further analyses which assessed the regulatory significance of the GSI-191 parametric study's conclusion, the NRC staff has determined that it is appropriate to generically request that PWR licensees evaluate the potential for sump screen blockage under mechanistically determined debris loadings.

Considering the potential risk-significance associated with a degraded ECCS and CSS, ~~the NRC staff is also requesting that addressees implement appropriate interim compensatory measures to ensure that the potential risks due to sump clogging are adequately managed~~and <u>the extended duration that may be required to complete the requested evaluation, addressees may find that it is warranted to devote increased attention to risk management</u> until all necessary corrective actions are complete. Therefore, in accordance with Generic Letter 91-

18, ~~Revision 1, the requested~~Revision 1, the NRC staff is requesting that addressees assess whether the implementation of interim compensatory measures is necessary to ensure that potential interim risks due to sump clogging are adequately being managed. Consistent with Generic Letter 91-18, Revision 1, compensatory measures are intended as "an interim step to restore operability or to otherwise enhance the capability" of the recirculation sump screen. In particular, the NRC staff considers interim compensatory measures to be appropriate for addressees that non-conservatively rely upon the 50%-blockage assumption to demonstrate ECCS or CSS operability, despite their plants' containing quantities of debris inside containment which could uniformly accumulate to block essentially the entire screen surface area during a postulated accident. As a spectrum of conditions exists with respect to both the susceptibility of specific PWRs to sump clogging and the options available to each addressee for mitigating sump screen blockage, addressees should consider a range of potential interim compensatory measures and implement those which they deem appropriate (if any), based upon the specific conditions associated with their plants. Possible interim compensatory measures ~~could~~ include operator training on indications of and responses to sump clogging, modified operational procedures that would delay the switchover to containment sump recirculation, more extensive containment cleaning, increased foreign material controls, and plant modifications. The potential risk benefit of certain operator responses to sump clogging is demonstrated in the NRC-sponsored technical report LA-UR-02-7562, entitled, "The Impact of Recovery from Debris-Induced Loss of ECCS Recirculation on PWR Core Damage Frequency," and dated February 2003.

Furthermore, although the parametric study focused on the potential for debris to clog containment recirculation sumps, operating experience and the NRC's efforts to resolve GSI-191 have identified three related modes by which debris blockage could impede or prevent ECCS and CSS recirculation. As explained in the following paragraphs, these debris blockage effects are integrally related to sump screens' design function of intercepting potentially harmful debris, while accommodating ECCS and CSS design flow rates and pump suction requirements. Therefore, the NRC is requesting that, in conjunction with sump clogging, addressees consider the three concerns discussed below in performing a systematic, plant-specific assessment of the capability of containment recirculation sump screens to adequately protect the ECCS and CSS recirculation functions against potentially deleterious effects of conservative post-accident debris loadings.

First, most PWR sump screens were not specifically designed to accommodate the structural loadings that would result from the differential pressure across the screen when quantities of debris that the NRC's GSI-191 research program has demonstrated to be credible accumulate uniformly over the entire screen surface. At the time most PWRs were licensed, the aforementioned 50%-blockage assumption was used to evaluate sump screen design adequacy. This assumption, in addition to leading to non-conservative NPSH calculations for pumps taking suction from the recirculation sump, also resulted in an underestimation of the structural loadings on the sump screen resulting from plausible debris beds that cover essentially the entire screen surface area. Consequently, PWR sump screens may be susceptible to deformation, damage, or failure under expected debris loadings. Significant damage to or a failure of a recirculation sump screen could allow large quantities of debris to be ingested into the ECCS and CSS piping, pumps, and other components, potentially leading to their clogging or failure. The ECCS strainer plugging and deformation events that occurred at Perry Unit 1, which are further described in Information Notice (IN) 93-34, "Potential for Loss of Emergency Cooling Function Due to a Combination of Operational and Post-LOCA Debris in Containment," and Licensee Event Report (LER) 50-440/93-011, "Excessive Strainer Differential Pressure Across the RHR Suction Strainer Could Have Compromised Long Term Cooling During Post-LOCA Operation," demonstrate the credibility of this concern for screens and strainers that have not been designed with adequate reinforcement.

Second, in some PWR containments, the flowpaths by which containment spray or break flows return to the recirculation sump may include "choke-points," at which the flowpath becomes constricted to the extent that it could become blocked with debris during an accident. For example, choke-points may include drains for pools, cavities, or isolated containment compartments, and constricted drainage paths between separated containment elevations. Debris blockage at certain choke-points could result in substantial amounts of water required for adequate recirculation to be held up or diverted into regions of containment that do not drain to the recirculation sump. The loss of water assumed to be available to support sump recirculation could result in an available NPSH for ECCS and CSS pumps that is lower than the analyzed value, thereby reducing the assurance that recirculation would successfully function. A reduced available NPSH directly concerns sump screen design because the NPSH margin of the ECCS and CSS pumps must be conservatively calculated to correctly determine the required surface area of passive sump screens when mechanistically determined debris loadings are considered. Although the parametric study (NUREG/CR-6762, Volume 1) did not analyze in detail the potential for the diversion of recirculation sump inventory, the NRC's GSI-191 research identified this phenomenon as an important and potentially credible concern. A number of LERs have also been generated associated with this concern, which further confirm both its credibility and potential significance. These LERs include:

- LER 50-369/90-012, "Loose Material Was Located in Upper Containment During Unit Operation Because of an Inappropriate Action," McGuire Unit 1.
- LER 50-266/97-006, "Potential Refueling Cavity Drain Failure Could Affect Accident Mitigation," Point Beach Unit 1.
- LER 50-455/97-001, "Unit 2 Containment Drain System Clogged Due to Debris," Byron Unit 2.
- LER 50-269/97-010, "Inadequate Analysis of ECCS Sump Inventory Due to Inadequate Design Analysis," Oconee Unit 1.
- LER 50-315/98-017, "Debris Recovered from Ice Condenser Represents Unanalyzed Condition," D. C. Cook Unit 1.

Third, as elaborated in the Background section of this generic letter, debris blockage at flow restrictions within the ECCS recirculation flowpath downstream of the sump screen is a potential concern for PWRs. Debris that is capable of passing through the recirculation sump screen may have the potential to become lodged at a downstream flow restriction in the ECCS recirculation flowpath, such as a HPSI throttle valve or fuel assembly inlet debris screen. Debris blockage at such flow restrictions in the ECCS flowpath could impede or prevent the recirculation of coolant to the reactor core, thereby leading to inadequate core cooling. Similarly, debris blockage at flow restrictions in the CSS flowpath could impede or prevent CSS recirculation, thereby leading to inadequate containment heat removal. Considering the recirculation sump screen's design function of intercepting potentially harmful debris, an assessment of the potential for downstream blockage is necessary to determine whether the screen openings are appropriately sized.

The Nuclear Energy Institute (NEI) is currently developing a two-step guidance program, which addressees may use to facilitate the plant-specific sump-clogging evaluations that the NRC is requesting in this generic letter. In September 2002, NEI published Revision 1 of the initial guidance document, NEI 02-01, "Condition Assessment Guidelines: Debris Sources Inside PWR Containments." NEI 02-01 contains guidelines for performing inventories of potential debris sources inside containment. In September 2003, NEI plans to publish the second guidance document, which will recommend methodologies for evaluating a PWR's susceptibility to sump clogging based upon the information collected in accordance with NEI 02-01.

The NRC staff is monitoring the development of NEI's sump evaluation guidance program. At present, the NRC staff cannot offer an unqualified endorsement of the program because NEI's guidance concerning sump evaluation methodologies is unfinished. However, NEI considered the staff's comments concerning Revision 0 of NEI 02-01 (published in April 2002), incorporated many of them into Revision 1 of NEI 02-01, and has indicated a similar willingness to address the staff's comments concerning the forthcoming evaluation methodology guidance. Therefore, the staff expects that NEI's program will constitute an acceptable approach for performing the evaluation requested by this generic letter. If NEI's forthcoming evaluation methodology guidance document is not completely acceptable, it may become necessary for the NRC to issue a supplemental generic communication to apprise PWR licensees of the NRC's exceptions or additions to NEI's guidance. Addressees may also use alternative approaches to NEI's guidance for performing the requested evaluations; however, additional staff review may be required to assess their adequacy.

Applicable Regulatory Requirements

NRC regulations in Title 10, Section 50.46, of the *Code of Federal Regulations* (10 CFR 50.46) require that the ECCS must satisfy five criteria, one of which is to provide the capability for long-term cooling of the reactor core. The ECCS must have the capability to provide decay heat removal, such that the core temperature is maintained at an acceptably low value for the extended period of time required by the long-lived radioactivity remaining in the core. For PWRs licensed to the General Design Criteria (GDCs) in Appendix A to 10 CFR Part 50, GDC 35 specifies additional ECCS requirements.

Similarly, for PWRs licensed to the GDCs in Appendix A to 10 CFR Part 50, GDC 38 provides requirements for containment heat removal systems, and GDC 41 provides requirements for containment atmosphere cleanup. Many PWR licensees credit a CSS, at least in part, with performing the safety functions to satisfy these requirements, and PWRs that are not licensed to the GDCs may similarly credit a CSS to satisfy licensing-basis requirements. In addition, PWR licensees may credit a CSS with reducing the accident source term to meet the limits of 10 CFR Part 100 or 10 CFR 50.67.

Applicable Regulatory Guidance

Draft Regulatory Guide 1107, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," to be published in February 2003.

Requested Actions

All addressees are requested to take the actions discussed below to ensure the capability of the ECCS and CSS to perform their safety functions following all postulated accidents for which ECCS or CSS recirculation is required:

(1) Perform an evaluation of the potential for the accumulation of debris to impede or prevent the recirculation functions of the ECCS and CSS following all postulated accidents for which the recirculation of these systems is required. As described in the Discussion section of this generic letter, most addressees' current licensing-basis analyses do not adequately and completely model sump screen debris blockage and related effects. Therefore, the requested evaluation should consider potential sources of debris, factors that affect debris transport and head-loss, and additional characteristics of the ECCS flowpath, recirculation sump, and containment flowpaths, as necessary, to evaluate each of the potential adverse effects of debris blockage identified in the Discussion section of this generic letter. As explained in the Discussion section, the requested evaluation may follow NEI's guidance or employ an alternative approach.

(2) Assess the necessity for and implement, if appropriate, interim compensatory measures ~~to prevent or mitigate the potential for~~, in accordance with Generic Letter 91-18, Revision 1, to adequately manage the interim risks associated with sump clogging until the requested evaluation is performed. ~~In accordance~~Consistent with Generic Letter 91-18, Revision 1~~, the requested~~ compensatory measures are intended as "an interim step to restore operability or to otherwise enhance the capability" of the recirculation sump screen. In particular, the NRC staff considers interim compensatory measures to be appropriate for addressees that non-conservatively rely upon the 50%-blockage assumption to demonstrate ECCS or CSS operability, despite their plants' containing quantities of debris inside containment which could uniformly accumulate to block essentially the entire screen surface area during a postulated accident. Addressees are requested to consider a range of potential interim compensatory measures, and to implement those that they deem appropriate (if any), based upon the design and condition of their specific facilities. Examples of potential interim compensatory measures include operator training on indications of and responses to sump screen clogging, modified operational procedures that would delay the switchover to containment sump recirculation, more extensive containment cleaning, increased foreign material controls, and plant modifications.

(3) Implement any plant modifications that the above evaluation identifies as being necessary to ensure compliance with NRC regulations. If power operation is planned between the time a modification is determined to be necessary and the time the modification will be implemented, addressees are also requested to reconsider the adequacy of the interim compensatory measures currently in effect. Generic Letter 91-18, Revision 1, provides guidelines concerning the need for the timely implementation of corrective actions and for evaluating the necessity and adequacy of interim compensatory measures.

Requested Information

All addressees are requested to provide the following information:

(1) Within 90 days of the date of this generic letter, provide the following information:

(a) a description of plans for a containment surveillance to collect the information needed to perform the requested evaluation of the ECCS and CSS recirculation functions, such as potential debris sources, containment flowpaths, and recirculation sump features. If a containment surveillance will not have been performed by the end of the upcoming refueling outage, provide a justification.

(b) a description of plans to perform the requested evaluation of the susceptibility of the recirculation functions of the ECCS and CSS to becoming degraded or interrupted as a result of debris blockage. If the planned completion date for the requested evaluation is not before April 1, 2004, or is not within 90 days of the completion of the containment surveillance, whichever is later, provide a justification.

(c) a description of any interim compensatory measures that have been or will be implemented to reduce the potential for and/or adverse effects of sump screen blockage until the requested evaluation is completed. If interim compensatory measures will not be implemented, provide a justification.

(2) Within 90 days of the date of completion of the requested evaluation of the susceptibility of the ECCS and CSS recirculation functions to debris blockage, provide the following information:

(a) a description of the actions taken to ensure the availability of the recirculation functions of the ECCS and CSS. At a minimum, this description should include the following information:

(i) an overview of the methodology used for evaluating the susceptibility of the ECCS and CSS recirculation functions to debris blockage and for performing the supporting containment walkdown surveillance. If the methodology followed was NEI's guidance (including any potential NRC exceptions and additions thereto), a reference to that effect will suffice, provided that significant deviations are noted.

(ii) a general description of the pipe break locations chosen for evaluation, and a justification that the breaks evaluated encompass the debris loadings for all postulated accidents requiring ECCS or CSS recirculation.

(iii) a general description of and expected implementation schedule for any plant modifications that are necessary to ensure the availability of the ECCS and CSS recirculation functions under postulated debris loadings. If required modifications will not have been completed by the end of the subsequent refueling outage, provide a justification.

(b) if any plant modifications that are identified as being necessary to ensure compliance with NRC regulations and other regulatory requirements will not be implemented until a future scheduled outage, describe any interim compensatory measures that will be in place until these future modifications are implemented.

(c) a safety assessment concerning the adequacy of the ECCS and CSS recirculation functions under postulated debris loading conditions. The safety assessment should evaluate the configuration of the plant that will exist once all required modifications have been made. At a minimum, this assessment should include the following information:

(i) the available NPSH margin for the ECCS and CSS pumps with an unblocked sump screen.

(ii) the submergence of the sump screen (i.e., partial or full) at the time of the switchover to sump recirculation, and the submerged area of the sump screen at this time.

(iii) the maximum head-loss postulated as a result of debris blockage on the sump screen and a characterization of the primary constituent(s) of the debris bed that results in this head-loss.

(iv) a brief discussion concerning the credibility of debris blockage at choke-points in containment recirculation sump return flowpaths that would result in substantial amounts of water required to ensure adequate ECCS or CSS recirculation being held up or diverted away from the recirculation sump.

(v) a brief discussion concerning the credibility of inadequate core cooling to occur due to debris blockage at flow restrictions in the ECCS flowpath downstream of the sump screen, such as a HPSI throttle valve or fuel assembly inlet debris screen.

(d) a description of any programmatic controls that would ensure that, in the future, potential sources of debris introduced into containment (e.g., insulations, signs, coatings, and foreign materials) would be assessed for potential adverse effects to the recirculation functions of the ECCS and CSS. Addressees may reference their responses to Generic Letter 98-04 to the extent that their responses address these specific foreign material control issues.

Required Response

In accordance with 10 CFR 50.54(f), the NRC requires each addressee to respond as described above. The NRC needs this information to verify addressees' compliance with NRC regulations and their current licensing bases.

Within 90 days of the date of this generic letter, each addressee is required to submit a written response that includes the information requested above in Item 1 of the Requested Information section. Within 90 days of completing the evaluation of the susceptibility of the ECCS and CSS recirculation functions to debris blockage, each addressee is required to submit a written response that includes the information requested above in Item 2 of the Requested Information section. Addressees who choose not to submit the requested information must describe in their response any alternative courses of action that they propose to take, including the basis for the acceptability of the proposed alternative courses of action.

The required written responses should be addressed to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001, under oath or affirmation under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). A copy of each response should be sent to the appropriate regional administrator.

The NRC staff will review the responses to this generic letter and, if concerns are identified, will notify affected addressees. The staff may also conduct inspections to determine addressees' effectiveness in addressing this generic letter.

Reasons for Information Request

As discussed above, recent research and analysis suggests that: (1) the potential for the failure of the ECCS and CSS recirculation functions as a result of debris blockage is not adequately addressed in most PWR licensees' current safety analyses, and (2) the ECCS and CSS recirculation functions at a significant number of operating PWRs could become degraded as a result of the potential effects of debris blockage identified in this generic letter. An ECCS that is incapable of providing long-term reactor core cooling through recirculation operation would be in violation of 10 CFR 50.46. A CSS that is incapable of functioning in recirculation mode may not comply with GDCs 38 and 41, or other plant-specific licensing requirements or safety analyses. Furthermore, as increases in risk could be associated with a degraded ECCS and CSS, it may be appropriate for addressees to implement compensatory measures until the degraded condition is corrected. Therefore, the information requested in this generic letter is necessary to permit the assessment of plant-specific compliance with NRC regulations and to ensure that the public safety is being adequately protected.

The NRC staff will also use the requested information to assess the need for and to guide the development of any additional regulatory actions that may be necessary to address the adequacy of the ECCS and CSS recirculation functions under anticipated debris loading conditions.

Related Generic Communications

- Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors," May 6, 1996.
- Bulletin 95-02, "Unexpected Clogging of a Residual Heat Removal (RHR) Pump Strainer While Operating in the Suppression Pool Cooling Mode," October 17, 1995.
- Bulletin 93-02, "Debris Plugging of Emergency Core Cooling Suction Strainers," May 11, 1993.
- Bulletin 93-02, Supplement 1, "Debris Plugging of Emergency Core Cooling Suction Strainers," February 18, 1994.
- Generic Letter 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System After a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," July 14, 1998.
- Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," October 7, 1997.
- Generic Letter 85-22, "Potential For Loss of Post-LOCA Recirculation Capability Due to Insulation Debris Blockage," December 3, 1985.
- Information Notice 97-13, "Deficient Conditions Associated With Protective Coatings at Nuclear Power Plants," March 24, 1997.
- Information Notice 96-59, "Potential Degradation of Post Loss-of-Coolant Recirculation Capability as a Result of Debris," October 30, 1996.
- Information Notice 96-55, "Inadequate Net Positive Suction Head of Emergency Core Cooling and Containment Heat Removal Pumps Under Design Basis Accident Conditions," October 22, 1996.
- Information Notice 96-27, "Potential Clogging of High Pressure Safety Injection Throttle Valves During Recirculation," May 1, 1996.

- Information Notice 96-10, "Potential Blockage by Debris of Safety System Piping Which Is Not Used During Normal Operation or Tested During Surveillances," February 13, 1996.

- Information Notice 95-47, "Unexpected Opening of a Safety/Relief Valve and Complications Involving Suppression Pool Cooling Strainer Blockage," October 4, 1995.

- Information Notice 95-47, Revision 1, "Unexpected Opening of a Safety/Relief Valve and Complications Involving Suppression Pool Cooling Strainer Blockage," November 30, 1995.

- Information Notice 95-06, "Potential Blockage of Safety-Related Strainers by Material Brought Inside Containment," January 25, 1995.

- Information Notice 94-57, "Debris in Containment and the Residual Heat Removal System," August 12, 1994.

- Information Notice 93-34, "Potential for Loss of Emergency Cooling Function Due to a Combination of Operational and Post-LOCA Debris in Containment," April 26, 1993.

- Information Notice 93-34, Supplement 1, "Potential for Loss of Emergency Cooling Function Due to a Combination of Operational and Post-LOCA Debris in Containment," May 6, 1993.

- Information Notice 92-85, "Potential Failures of Emergency Core Cooling Systems Caused by Foreign Material Blockage," December 23, 1992.

- Information Notice 92-71, "Partial Plugging of Suppression Pool Strainers at a Foreign BWR," September 30, 1992.

- Information Notice 89-79, "Degraded Coatings and Corrosion of Steel Containment Vessels," December 1, 1989.

- Information Notice 89-79, Supplement 1, "Degraded Coatings and Corrosion of Steel Containment Vessels," June 29, 1990.

- Information Notice 89-77, "Debris in Containment Emergency Sumps and Incorrect Screen Configurations," November 21, 1989.

- Information Notice 88-28, "Potential for Loss of Post-LOCA Recirculation Capability Due to Insulation Debris Blockage," May 19, 1988.

Backfit Discussion

Under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.109(a)(4)(i), this generic letter requests actions to ensure compliance with the existing applicable regulatory requirements previously outlined in this generic letter. Specifically, this generic letter requests that addressees evaluate their facilities for regulatory compliance, perform any modifications or actions that may be necessary to restore compliance therewith, and take appropriate compensatory measures if a degraded condition exists. Thus, the actions requested by this generic letter are considered a compliance backfit in accordance with 10 CFR 50.109(a)(4)(i), and the staff has not performed a detailed backfit analysis. However, the NRC staff did perform a simplified backfit analysis, which is publicly available in the NRC's Agencywide Documents Access and Management System (ADAMS) under Accession Number ML012750414.

Small Business Regulatory Enforcement Fairness Act

The NRC has determined that this generic letter is not subject to the Small Business Regulatory Enforcement Fairness Act of 1996.

Federal Register Notification

The NRC published a notice of opportunity for public comment on this generic letter in the *Federal Register* on .... In addition, the NRC has provided opportunities for public comment at several public meetings. As the resolution of this matter progresses, the NRC will continue to provide opportunities for further public involvement.

Paperwork Reduction Act Statement

This generic letter contains information collections that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.) These information collections were approved by the Office of Management and Budget (OMB), under approval number 3150-0011, which expires on July 31, 2003.

The burden to the public for these mandatory information collections is estimated to average 200 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the necessary data, and completing and reviewing the information collections. Send comments regarding this burden estimate or any other aspect of these information collections, including suggestions for reducing the burden, to the Records Management Branch, Mail Stop T-6 E6, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by Internet electronic mail to INFOCOLLECTS@NRC.GOV; and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202 (3150-0011), Office of Management and Budget, Washington, DC 20503.

Public Protection Notification

The NRC may neither conduct nor sponsor, and an individual is not required to respond to, an information collection unless the requesting document displays a currently valid OMB control number.

If you have any questions about this matter, please contact the technical contacts or lead project manager listed below.

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United States Nuclear Regulatory Commission

GSI-191 "ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

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Office of Nuclear Reactor Regulation
Director Division of Systems Safety and Analysis

February 6, 2003

GSI-191 Presentation

- RES Study Concluded that PWR Sump Concerns were Credible but Need to be Addressed on Plant Specific Basis
  - More and finer debris could be generated by a HELB
  - Sump clogging due to more and finer debris
- ACRS Involvement requested
  - MD 6.4 role to Advise the Staff on the processes and methodologies for addressing Generic Safety Issues
  - OL 701 Role to Review selected CRGR Generic Communication packages before Public Comment Stage

GSI-191 Presentation

- Justification for Interim Operation
  - Low probability of LOCA requiring recirculation
  - Higher frequency LOCAs more time to or no recirculation, less debris, operator recovery potential
  - Likelihood qualified piping will leak before break
  - Margins in NPSH available, uncredited containment overpressure, cavitation operation potential
  - PWR containment/sump compartmentalized configuration
  - Ongoing industry actions to improve sumps and increase containment cleanliness
  - Ongoing configuration assessment walkdowns

Resolution Process for GSI-191

- Activities include
  - Revise Regulatory Guide 1.82
  - PWR Industry Initiative to Develop Guidance for Plant Specific Evaluation
  - Generic Letter
- Plant specific assessment needed to assure the reliability of ECCS in recirculation
- PWR industry to develop guidance acceptable to NRC to evaluate configurations
- Oversee evaluations of recirculation adequacy
  - Review generic letter responses
  - Sample audits of evaluations
  - Temporary instruction to allow inspection oversight of activities

United States Nuclear Regulatory Commission

STATUS AND PROPOSED RESOLUTION OF GSI-191 "ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

Ralph E. Architzel

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Office of Nuclear Reactor Regulation

Division of Systems Safety and Analysis

Plant Systems Branch

February 6, 2003

Generic Safety Issue GSI -191

- 10 CFR 50.46 (b)(5) and Appendix A to 10 CFR 50, Criterion 35 Require Long Term Emergency Core Cooling
- Debris Blockage of Sump Screens may Prevent the Injection of Water into the Reactor Core or Containment Spray
- USI A-43 Examined Emergency Sump Performance
  - closed in 1985 (Generic Letter 85-22; Reg Guide 1.82 Rev. 1)
- GSI -191 (1996) Re-Assesses Effect of Debris Accumulation on PWR Sump Performance due to
  - Events at BWRs
  - New information identified since USI A-43 closure, including BWR resolution
  - RES completed Technical Assessement; currently in regulations and guidance development stage

United States Nuclear Regulatory Commission

LANL Support Activities

- NRR Contracted LANL for technical support
- Provides continuity of GSI issue and related technical support
- Completing a set of calculations for volunteer plant
- Commenting on Industry Evaluation Guidelines
- Addressed testing or knowledge base uncertainties
- Evaluated potential operator recovery actions to complement parametric study results

Industry Meetings/Initiatives

- NEI PWR Sump Performance Task Force 1997
- Regular Meetings and Conference calls
- Since completion of Technical Assessment:
- March 28, 2002
  - NRC Action Plan addressed
  - Industry Initiative 6 Step program
    - No submittal but will coordinate with NRC
    - Regulatory Implementation for NRC action

NRC/PWR Industry Meetings (cont.)

- May 30, 2002
  - Presentation/discussion of Condition Assessment Guidelines (NEI-02-01)
- July 2, 2002
  - Review of potential interim actions and regulatory assessment
- July 30-31, 2002
  - NRC attended/presented at NEI PWR Sump Performance Workshop

NRC/PWR Industry Meetings (Cont.)

- August 29, 2002
  - Revision of Condition Assessment Guidelines (NEI-02-01) for NRC comments and Industry experience
  - Addition of HPSI throttle valve blockage to scope
- October 24, 2002
  - Status of action plan/GL
  - Discuss draft NEI Evaluation methodology ground rules
  - Discuss PCI letter concerning head loss due to fiber/particulate combinations
- November 18, 2002 - ANS Winter meeting session

NRC/PWR Industry Meetings (cont.)

- December 12, 2002
  - Additional ground rules sections presented
    - General Technical
    - Debris Generation
  - Discussed NRC perspectives on Design and Testing for GSI-191 Resolution
- Planned March 4, 2003
  - Status of action plan/GL/Operator Recovery TLR
  - Discuss NRC comments on NEI Evaluation methodology ground rules received
  - NEI present additional ground rules sections
  - Visit UNM Thermal Hydraulics laboratory

United States Nuclear Regulatory Commission

Current Plans and Schedules

- Issue Draft Generic Letter for Public Comment (First Quarter, 2003)
  - Following CRGR review
  - Draft GL is predecisional pending CRGR approval
- Issue Generic Letter (Summer 2003)
  - ACRS review before final if desired/substantive changes
- Industry (NEI) to Issue Guidance for Plant Specific Evaluation (September 2003)
  - ACRS meeting planned to present PWR IEG and NRC review
  - Final ACRS review of Generic Issue 191 at MPA closure stage

United States Nuclear Regulatory Commission

PROPOSED GENERIC LETTER 2003-XX "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION AT PRESSURIZED-WATER REACTORS"

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Office of Nuclear Reactor Regulation
Division of Systems Safety and Analysis
Plant Systems Branch
February 6, 2003

Purposes of Generic Letter

- Apprise PWR licensees of NRC research identifying the potential susceptibility of PWRs to containment recirculation sump screen blockage
- Apprise PWR licensees of additional adverse effects due to post-accident debris blockage
- Request that PWR licensees evaluate the ECCS and CSS recirculation functions, and, if appropriate, take additional actions to ensure their reliability
- Require that PWR licensees inform the NRC of the extent to which they will take the requested actions

Phenomenology

- Debris Generation
  - Primarily jet impingement
  - Secondarily temperature/humidity, flooding
- Pre-existing Debris Sources
- Debris Transport
  - Washdown from spray and break flows
  - Transport within pool if turbulence is sufficient
- Debris Accumulation
  - Suspended debris
  - Sliding debris

Concerns Addressed in Generic Letter

- Sump screen debris blockage
  - Potential loss of NPSH margin to ECCS and CSS pumps
  - Potential deformation of sump screens
- Upstream debris blockage at flow restrictions in containment drainage paths
- Downstream debris blockage at flow restrictions in ECCS and CSS

Requested Actions

- Perform a mechanistic evaluation of the susceptibility of the ECCS and CSS recirculation functions to debris blockage
- Assess necessity of, and, if appropriate, implement interim compensatory measures to mitigate the potential for sump clogging prior to performing evaluation
- Implement any plant modifications necessary to restore compliance with NRC regulations

United States Nuclear Regulatory Commission

Information Request

- GL cites 10 CFR 50.54(f) to require response
- Response is requested in two parts
- Purposes of information request:
  - To ensure PWR licensees have timely plans to perform requested actions
  - To ensure potential risks associated with sump clogging are being adequately managed
  - To elicit information concerning the results of the requested evaluation in support of resolving Generic Safety Issue 191

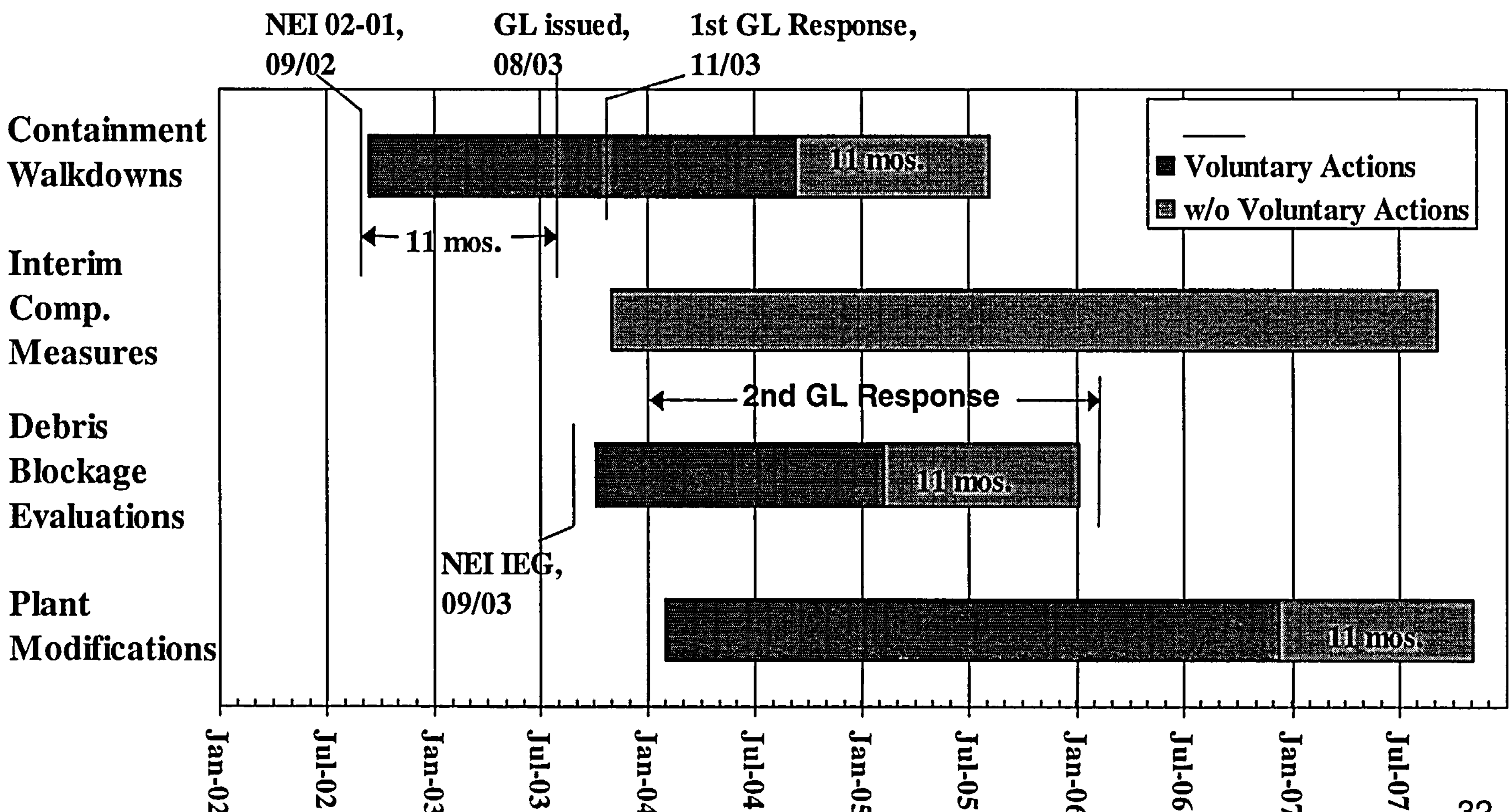
Coordination with Industry

- NEI is developing guidance for licensees to evaluate sump screen adequacy
- NEI addressed staff comments concerning guidance for containment surveillances
- NEI evaluation methodology guidance may be more challenging for reaching agreement
- GL tentatively endorses NEI guidance, but provides for potential disagreements

United States Nuclear Regulatory Commission

Licensee Resolution Actions

(For plants that are degraded but operable)



United States Nuclear Regulatory Commission

Draft Regulatory Guide, DG-1107 "Water Sources for Long-Term Recirculation Cooling Following A LOCA"

Dr. B. P. Jain
bpj@nrc.gov (301.415.6778)
Office of Nuclear Regulatory Research
Division of Engineering Technology
February 6, 2003

OVERVIEW

- Issuance Process
- Regulatory Guide 1.82, Rev. 3
- Current Plans and Schedules

United States Nuclear Regulatory Commission

Reg. Guide 1.82, Rev. 3 Issuance Process

- Brief ACRS on DG-1107
- Issue DG -1107 For Public Comment
- Resolve Public Comments
- Brief CRGR/ACRS
- Resolve Comments
- Issue Final Reg. Guide 1.82, Rev. 3

DG -1107(Regulatory Guide 1.82 Rev.3)

- Primarily, Revised PWR Sections to Enhance Guidance on Debris Blockage Evaluation
  - ❑ Consistent with BWRs Guidance in Rev.2, and,
  - ❑ Insights gained from Research Performed Under GSI -191
    - Debris Sources and Generation
    - Debris Transport
    - Debris Accumulation and Head Loss
- DG -1107 describes Analytical Approaches Acceptable to the staff
- Licensee can Propose Alternate Approaches
- Current Knowledgebase of Research on BWR Strainer and PWR Sump Screen Clogging Issue will be in NUREG/CR

Current plans and Schedules

- Issue Draft Regulatory Guide (DG-1107) for Public Comment (February, 2003)
- NRR Issue GL (Summer 2003)
- Brief ACRS on Final Reg. Guide (July 2003)
- Issue Final Regulatory Guide 1.82, Rev. 3 (September 2003)
- Industry (NEI) to Issue Guidance for Plant Specific Evaluation (Fall 2003)

PTS Re-Evaluation Project Briefing

Ed Hackett

Probabilistic Fracture Mechanics

(RES/DET/MEB)

Nathan Siu, Roy Woods, Donnie Whitehead, Alan Kolaczkowski

Probabilistic Risk Assessment

(RES/DRAA/PRAB)

David Bessette

Thermal Hydraulics

(RES/DSARE/SMSAB)

Sandia National Laboratories

An Employee-Owned Company

ACRS Meeting on PTS Re-Evaluation
USNRC Headquarters • Rockville, MD • 6th February 2003

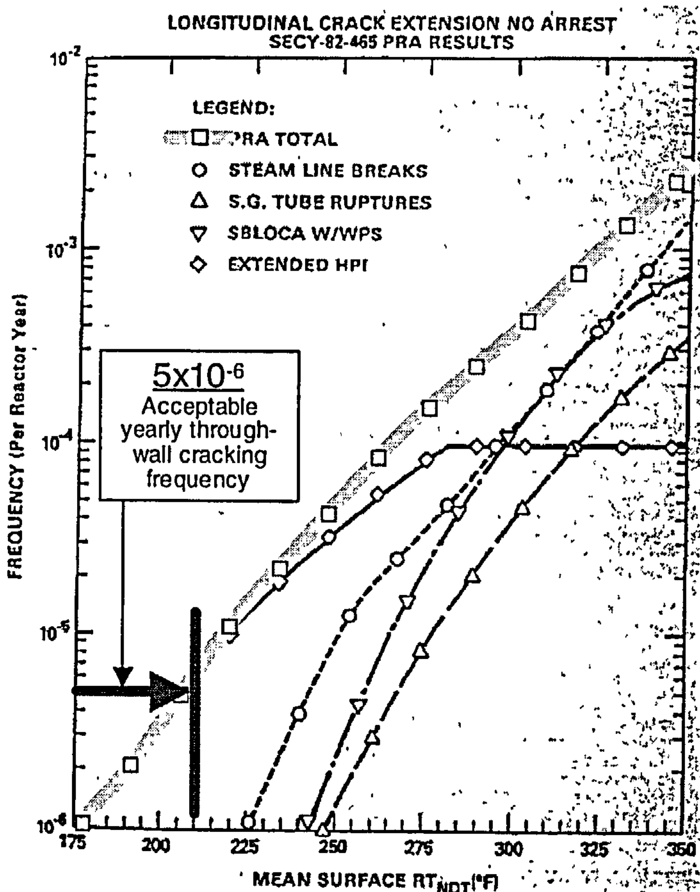
Briefing Overview

- 10CFR50.61 (the PTS rule)
  - Background & current implementation
  - Motivations for revision
- PTS re-evaluation project
  - Scope of analysis
  - Project conduct
  - Analysis approach
  - Results
  - Recommendations & significance
  - On-going activities

10CFR50.61

(Background & Current Implementation)

SECY-82-465 Basis



10CFR§50.61

If beltline materials are projected to exceed the RT_{NDT} screening limit at EOL, the licensee must either implement flux reduction and/or perform vessel specific analysis to justify continued operation.

- **10CFR 50.61: A multi-level structure**
  - **Compare deterministically computed RPV embrittlement (RT_{PTS}) against screening criteria**
  - **If necessary, employ reasonably practicable flux reduction measures**
  - **If necessary, perform plant specific analysis (RG 1.154) to justify continued operation**

10CFR50.61

(Motivations for Revision)

Yankee Rowe

- **In late 1980s the Yankee Rowe nuclear power plant waspredicted to exceed the 10CFR50.61 PTS screening criteria before EOL**
- **The Yankee Atomic Energy Company followed the provisions of Regulatory Guide 1.154 in an attempt to build a case supporting operation to embrittlement levels beyond the screening criteria**
- **Yankee Rowe was permanently shutdown in September of 1991**
- **The difficulties experienced with evaluation of the Yankee RG1.154 analysis led the Commission to direct the staff to revise the regulatory guide and associated rule**

10CFR50.61
(Motivations for Revision)

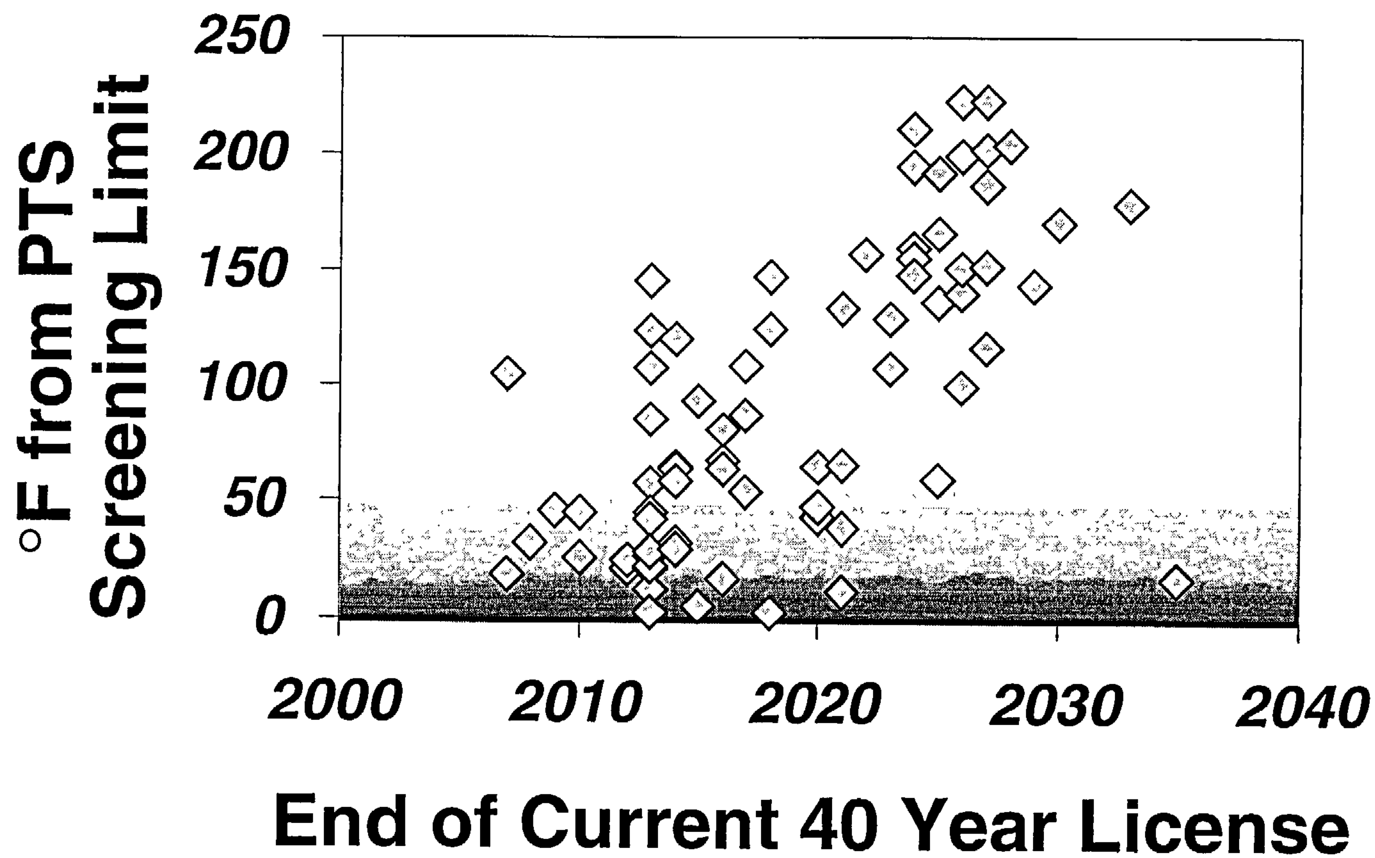
Technical Improvements made in the last 20 years suggest conservatism of the current rule.

- **PRA**
  - **Use of latest PRA/HRA data**
  - **More refined binning**
  - **Operator action credited**
  - **Acts of commission considered**
  - **External events considered**
  - **Medium and large-break LOCAs considered**
- **TH**
  - **Many more TH sequences modeled**
  - **TH code improved**
- **PFM**
  - **Significant conservative bias in toughness model removed**
  - **Spatial variation in fluence recognized**
  - **Most flaws now embedded rather than on the surface, also smaller**
  - **Material region dependent embrittlement props.**
  - **Non-conservatisms removed in arrest and embrittlement models removed**

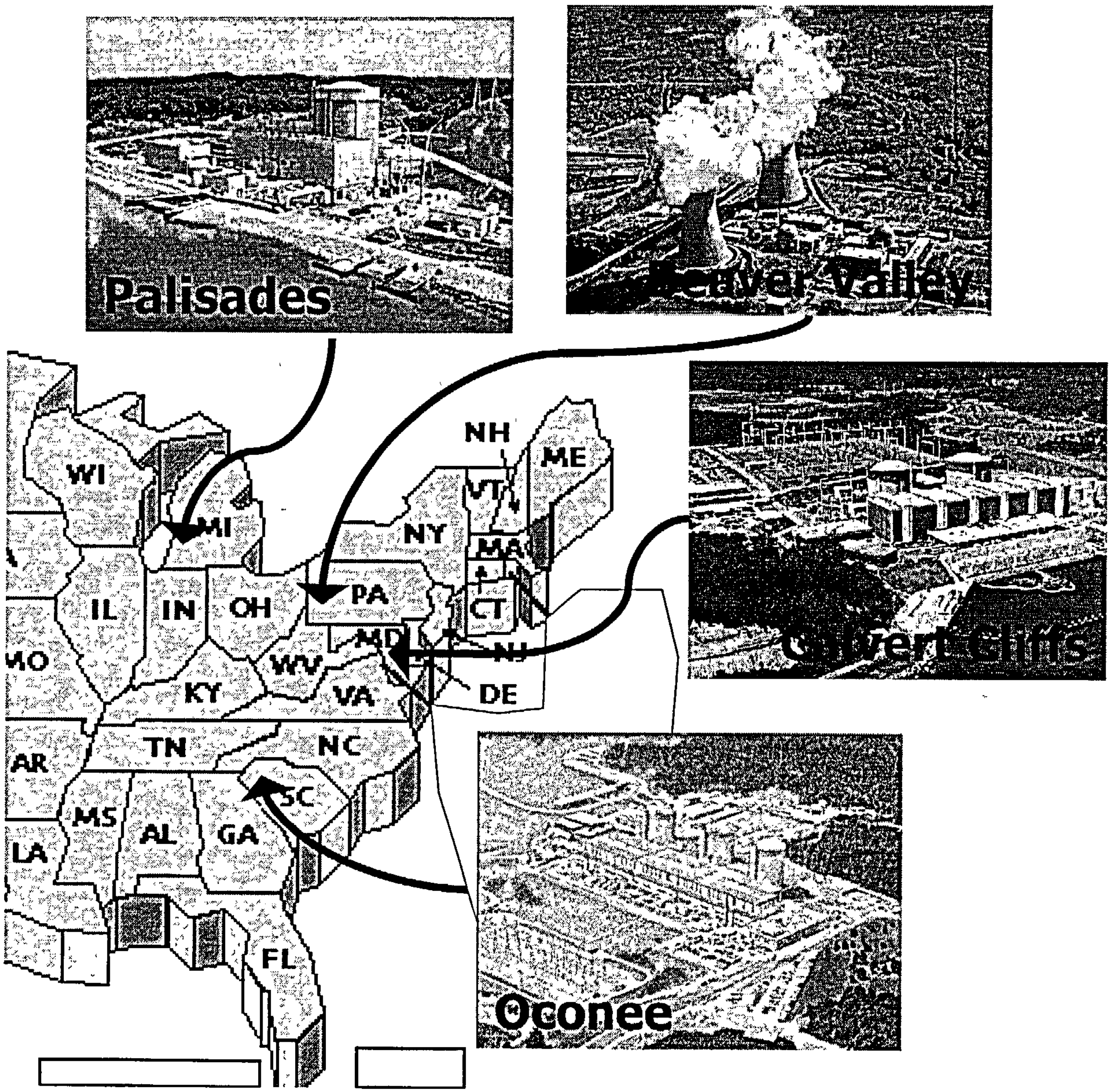
State of art analysis methods adopted throughout

10CFR50.61
(Motivations for Revision)

Some plants "close" to the current screening criteria → licensee exemption requests without a systematic process to address them.



Scope of Analysis



- **All PWR manufacturers**
  - **1 Westinghouse**
  - **2 CE**
  - **1 B&W**
- **2 plants from original (1980s) PTS study**
- **2 plants very close to the current PTS screening criteria**
- **All potential initiating event sequences considered**

Project Conduct

Broad Government and Industry Participation

United States Nuclear Regulatory Commission

EPRI

UT-Battelle

ornl

University of Maryland

Duke Energy

PEAI

PNL

Brookhaven National Laboratory

Consumers Energy
Count on Us

SAIC
An Employee-Owned Company

Sandia National Laboratories

FirstEnergy

Framatome

LSL

INEEL

Constellation Energy Group

SARTREX

VG 8

Analysis Approach

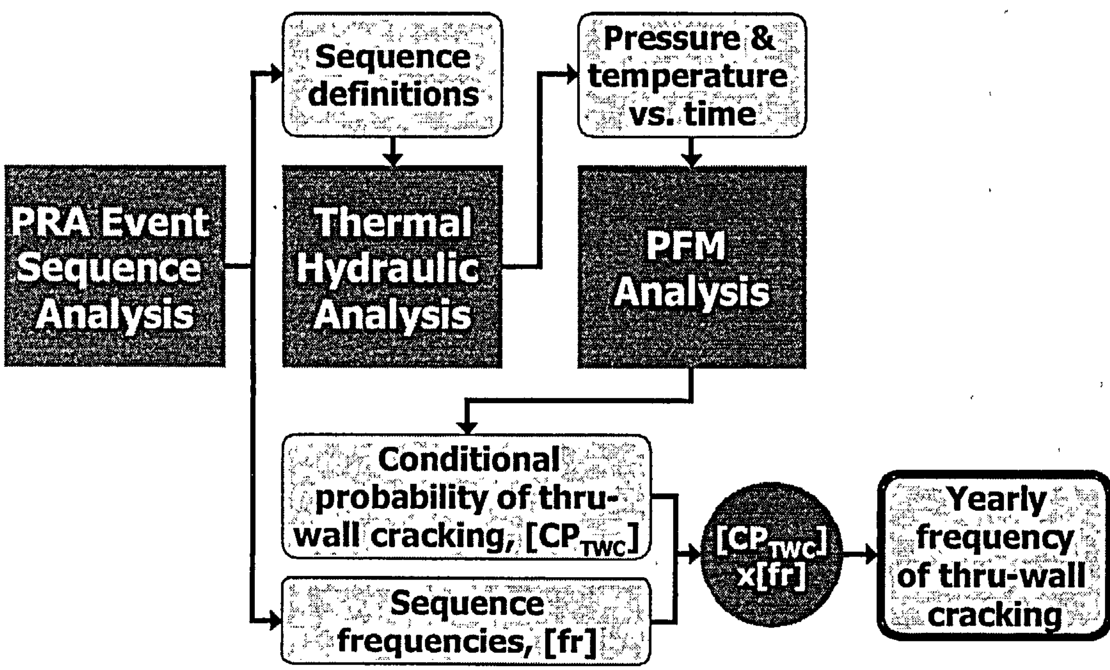
2 main components
- Plant TWC estimates
- Acceptable TWC frequency

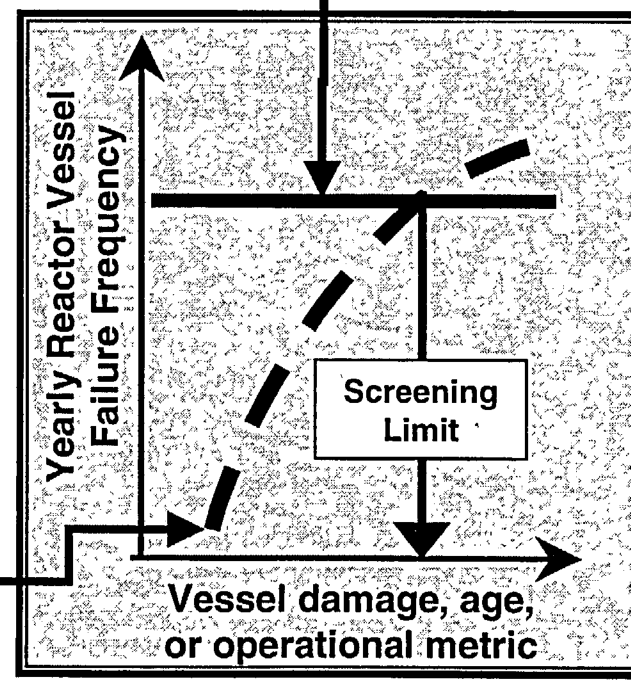
Acceptance Criterion for TWC Frequency

Consistent with
- 1986 Commission safety goal policy statement
- June 1990 SRM
- RG1.174

PLANT TWC ESTIMATES

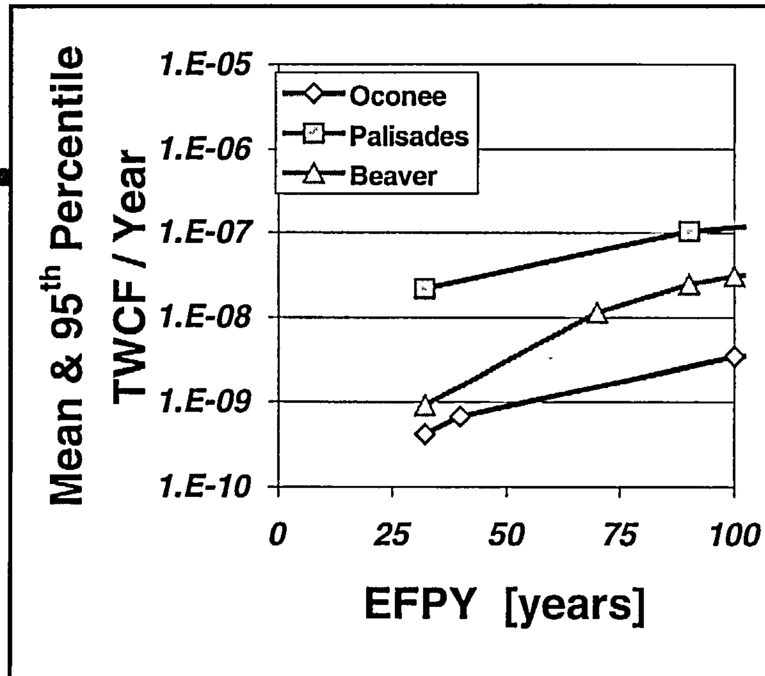
Uncertainties addressed and quantified as an integral part of the analysis process

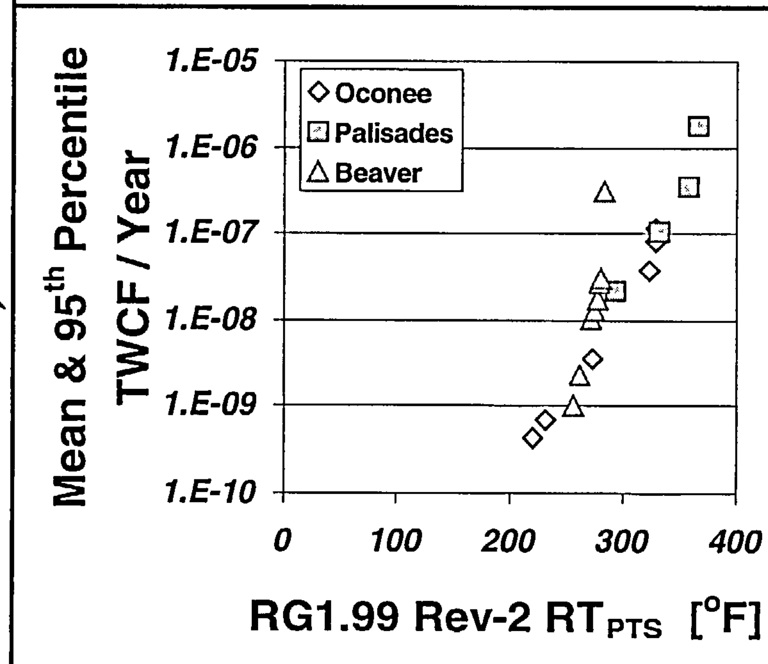




Results (1/5)

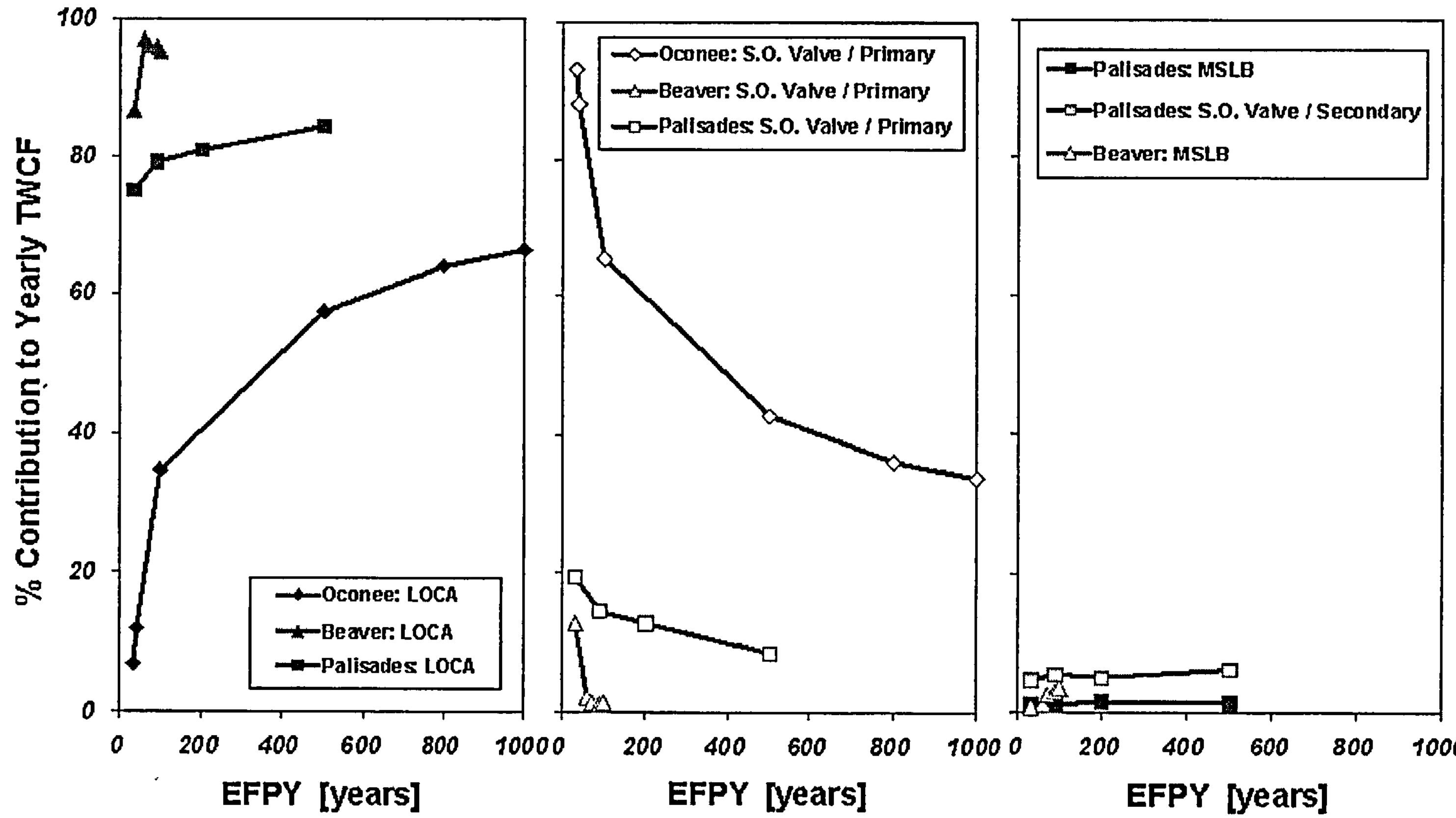
- **Over realistic operational lifetimes, the estimated TWCF for these plants is *VERY* small (from $1x10^{-9}$ to $5x10^{-8}$)**
- **At the current screening criteria the yearly TWCF is approximately $1x10^{-8}$**
- **Two of these plants have the highest level of embrittlement**





Results (2/5)

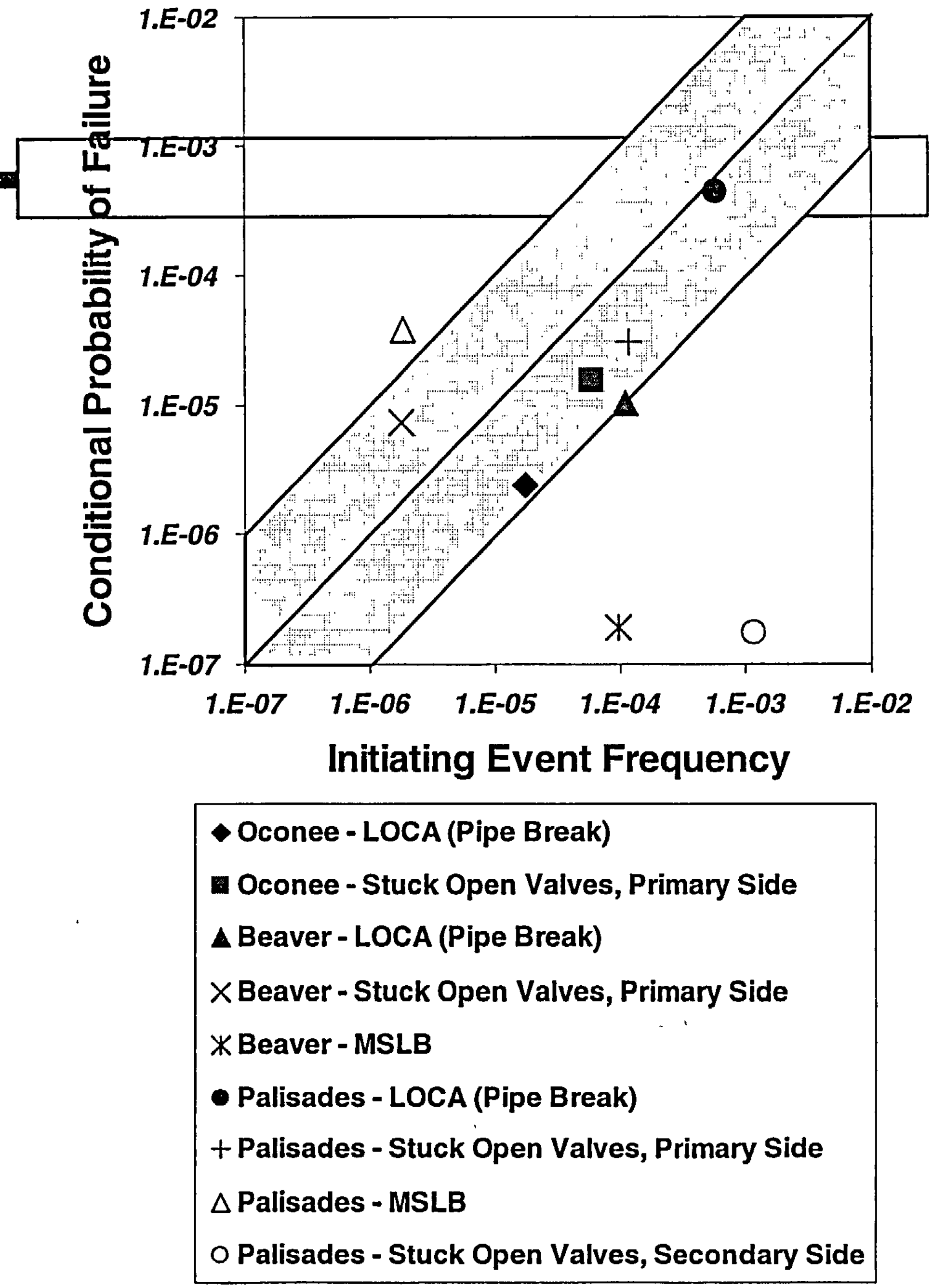
- LOCAs dominant contributor to risk
- Stuck open valves also a contributor in B&W PWRs due to plant design features
- Secondary side breaks not important



Results (3/5)

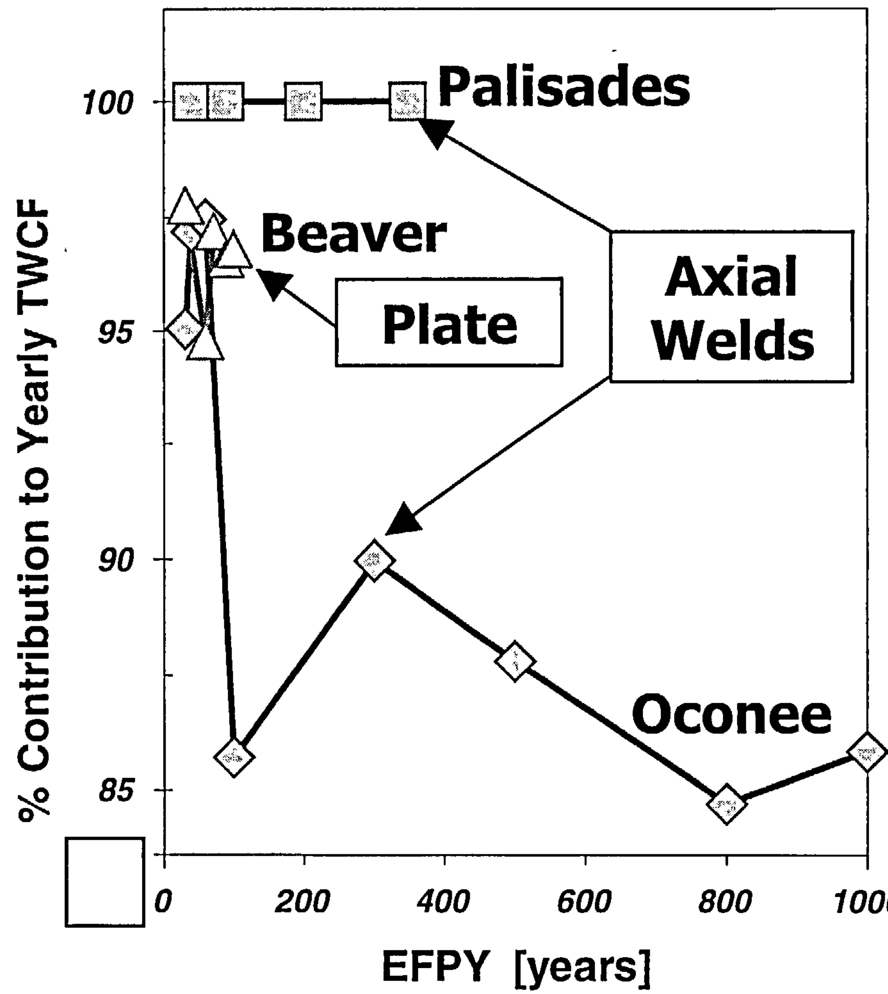
- **TWCF is the product of**
  - **The initiating event frequency, IEF, (X-axis), and**
  - **The conditional probability of failure, CPF, (Y-axis)**

- **The contribution of IEF and CPF to the through wall cracking frequency is approximately "balanced"**
  - **All but two of the dominant transient categories have IEFs and CPFs that are within about ±1 order of magnitude**



Results (4/5)

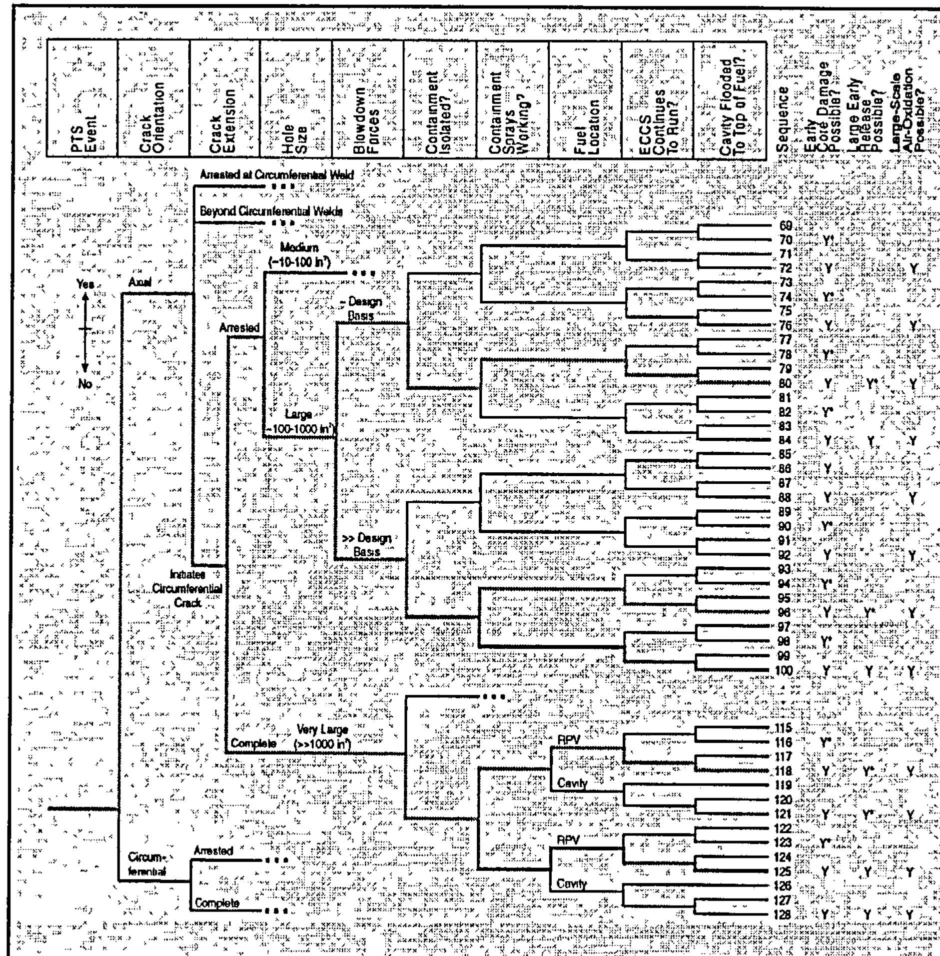
- Axial weld cracks dominate TWCF (≈90%)
  - Axial weld RT_{NDT}, or
  - Plate RT_{NDT}
- Circumferential weld cracks play a minor role in TWCF (≈10%)
  - Circ. weld RT_{NDT}, or
  - Plate RT_{NDT}
  - Forging RT_{NDT}
- Cracks in plates and forgings too small to play a role



Results (5/5)

- System energy lower than at time of RPV failure
  - Limited mechanical impulse
  - Limited containment pressurization
- No identified mechanisms for dependent failure of containment spray*
- Fuel cooling dependent on reactor cavity design

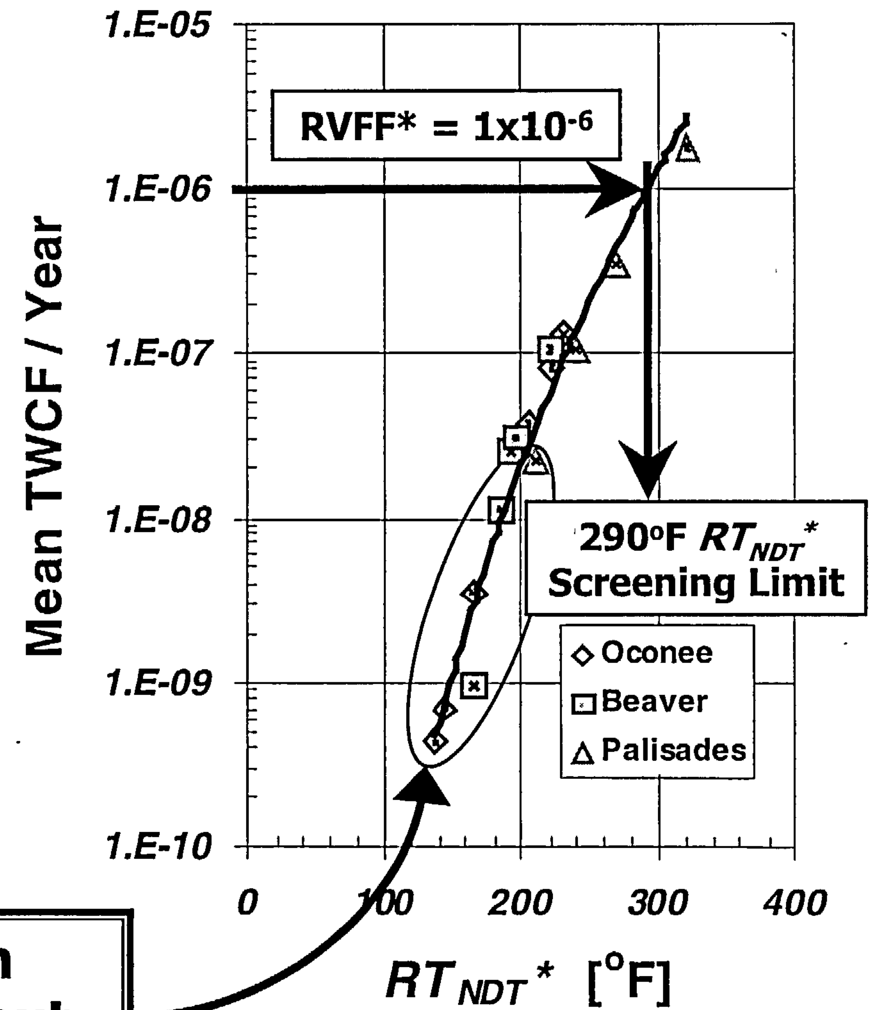
*May be dependent on plant changes in response to GSI-191



Suggested Embrittlement Metric

(& Significance)

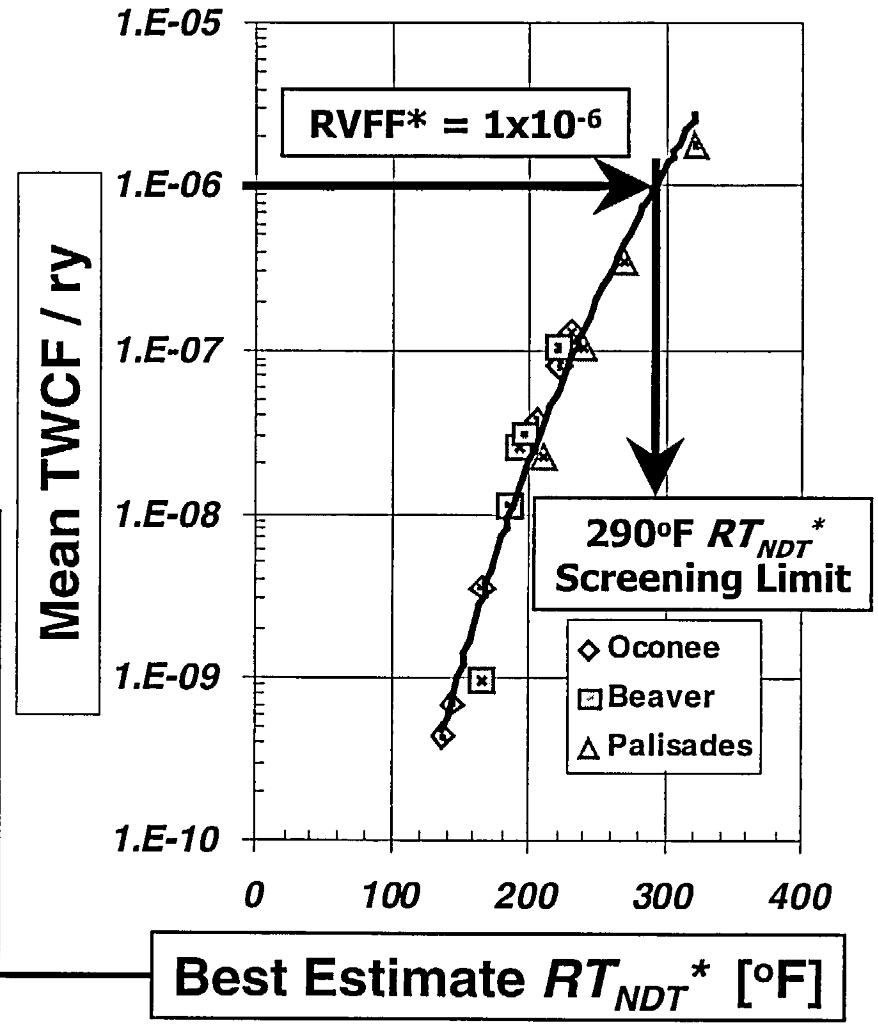
- ***VERY LOW*** **predicted TWCF values suggest that revision of the PTS rule & screening criteria is justified**
- **A yearly RVFF limit of $1x10^{-6}$ events corresponds to a weighted RT_{NDT} value ($RT_{NDT}*$) of 290°F**
- **Since $RT_{NDT}*$ is about 90°F less than RT_{PTS}, this suggests that a 80°F to 110°F increase of the current 10CFR50.61 screening limit is possible**



Results suggest that operation possible for 60 to 80 years without close approach to RVFF* limit.

RT_{NDT}* Screening Limit for PTS

- **Margin on RT_{NDT}* neither necessary nor appropriate**
  - **Maximum material uncertainties accounted for explicitly in FAVOR calculations – any plant state of knowledge will be better than we simulated**
- **290°F RT_{NDT}* limit pertains only to RT_{NDT}* estimated from**
  - **RVID $RT_{NDT(u)}$ values**
  - **Cu**
  - **Ni**
  - **P**



Conclusions

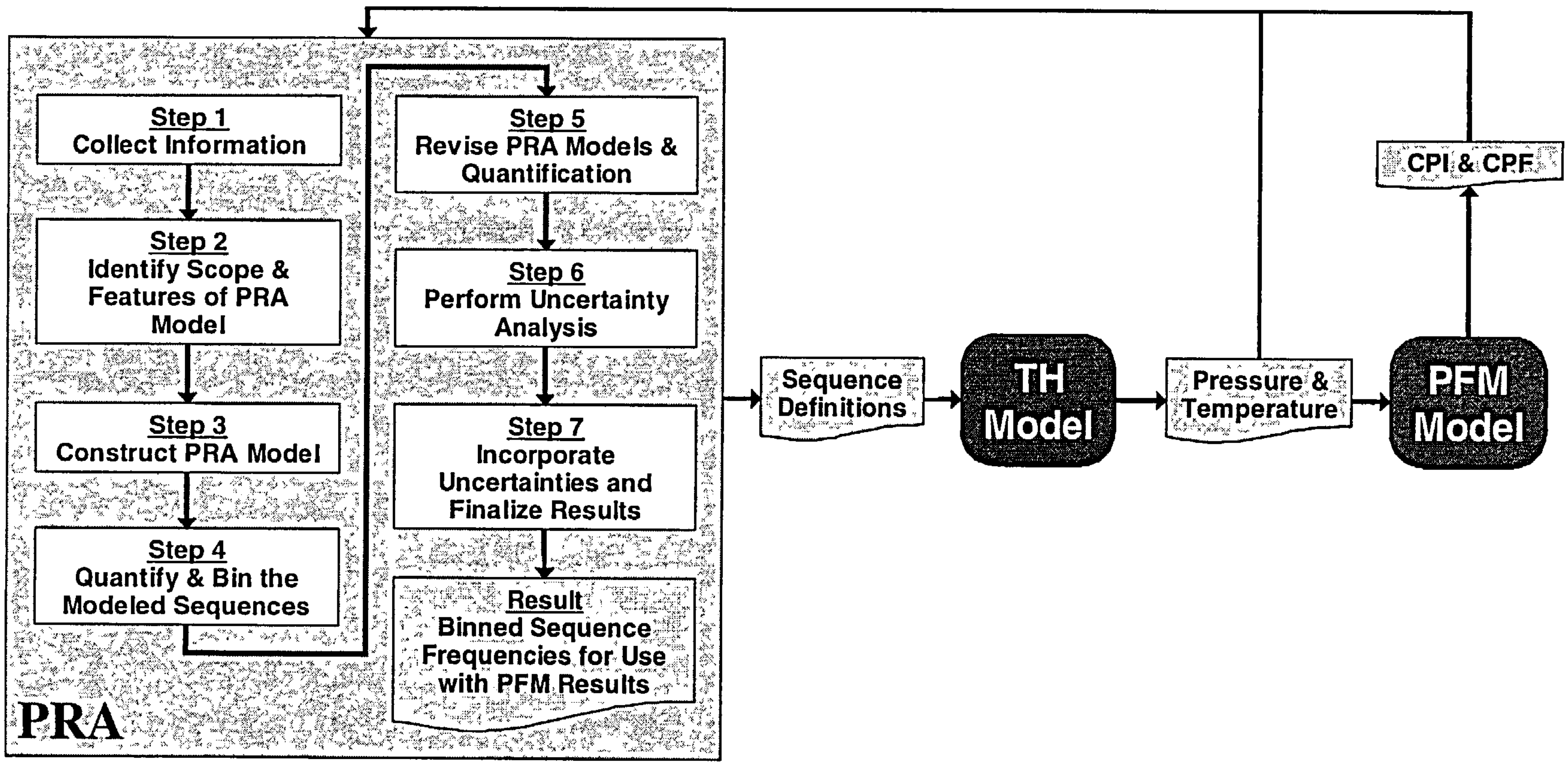
- **These analyses provide a technical basis to recommend revision of the PTS rule**
  - Two of the most embrittled plants in fleet have a TWCF at or below $5x10^{-8}$/ry at end of license extension (60 years)
  - At the 10CFR50.61 RT_{NDT} screening limits these plants have a TWCF of $1x10^{-8}$/ry (*vs.* RG 1.154 at $5x10^{-6}$/ry)
- **RVFF ≡ TWCF and RVFF* = 1 x 10^{-6}/ry**
  - Suggested criterion reflects margin between RPV failure and large early release
  - Suggested criterion consistent with philosophy of original PTS rule, ACRS guidance, Safety Goal QHOs
- **Analysis supports a revised screening limit of**
  - 290°F on a weighted RT_{NDT} value
    - ✓ Axial welds & plates dominate
    - ✓ Circ welds and forgings minor contributors
  - This limit is 80°F to 110°F higher than current 10CFR50.61 limits on RT_{PTS}

On-Going Activities

- **RES activities**
  - **Calvert cliffs**
  - **Generalization to all plants**
  - **Sensitivity studies & a more detailed examination of current results**
  - **Favor V&V**
  - **External peer review of project**
  - **Implications for operational limits (10CFR Appendix G)**
- **NRR activities**
  - **RES Draft NUREG sent to NRR on 12-31-02**
  - **NRR comments due by 3-31-03**
  - **Decision to proceed with rulemaking?**

Backup Slides

Details of PRA Event Sequence Analysis



Classes of Human Failures

Primary Integrity Control

- Operator fails to isolate an isolable LOCA in a timely manner (e.g., close a block valve to a stuck-open PORV)
- Operator induces a LOCA (e.g., opens a PORV) that induces/enhances a cooldown

Secondary Pressure Control

- Operator fails to isolate a depressurization condition in a timely manner
- Operator isolates when not needed (may create a new depressurization challenge, lose heat sink...)
- Operator isolates wrong path/SG (depressurization continues)
- Operator creates an excess steam demand such as opening turbine bypass/atmospheric dump valves

Secondary Feed Control

- Operator fails to stop/throttle or properly align feed in a timely manner (overcooling enhanced or continues)
- Operator feeds wrong (affected) SG (overcooling continues)
- Operator stops/throttles feed when inappropriate (causes underfeed, may have to go to feed and bleed & possible overcooling that way)

Primary Pressure/Flow Control

- Operator does not properly throttle/terminate injection to control RCS pressure
- Operator trips reactor coolant pumps (RCPs) when not suppose to and/or fails to restore them when desirable
- Operator does not provide sufficient injection or fails to trip RCPs appropriately (modeled as leading to core damage rather than a PTS concern)

Background: Post-SECY Discussions

- **Budgeting process: focus effort on assessing RVFF for pilot plants**

- **ACRS Letter (7/18/02; ML0220406120)**

  - **RVFF should be based on considerations of LERF (and not CDF)**
  - **Current LERF surrogate goal is not proper starting point**

"...source terms used to develop the current goal do not reflect the air-oxidation phenomena that would be a likely outcome of a PTS event."

  - **Options:**
    - ✓ **Develop acceptance criterion from prompt fatality safety goal**
    - ✓ **Use a frequency-based approach to develop RVFF* to provide assurance that PTS-induced RPV failures are very unlikely**
  - **ACRS' expectation: RVFF* will be substantially smaller than options proposed in SECY-02-0092**

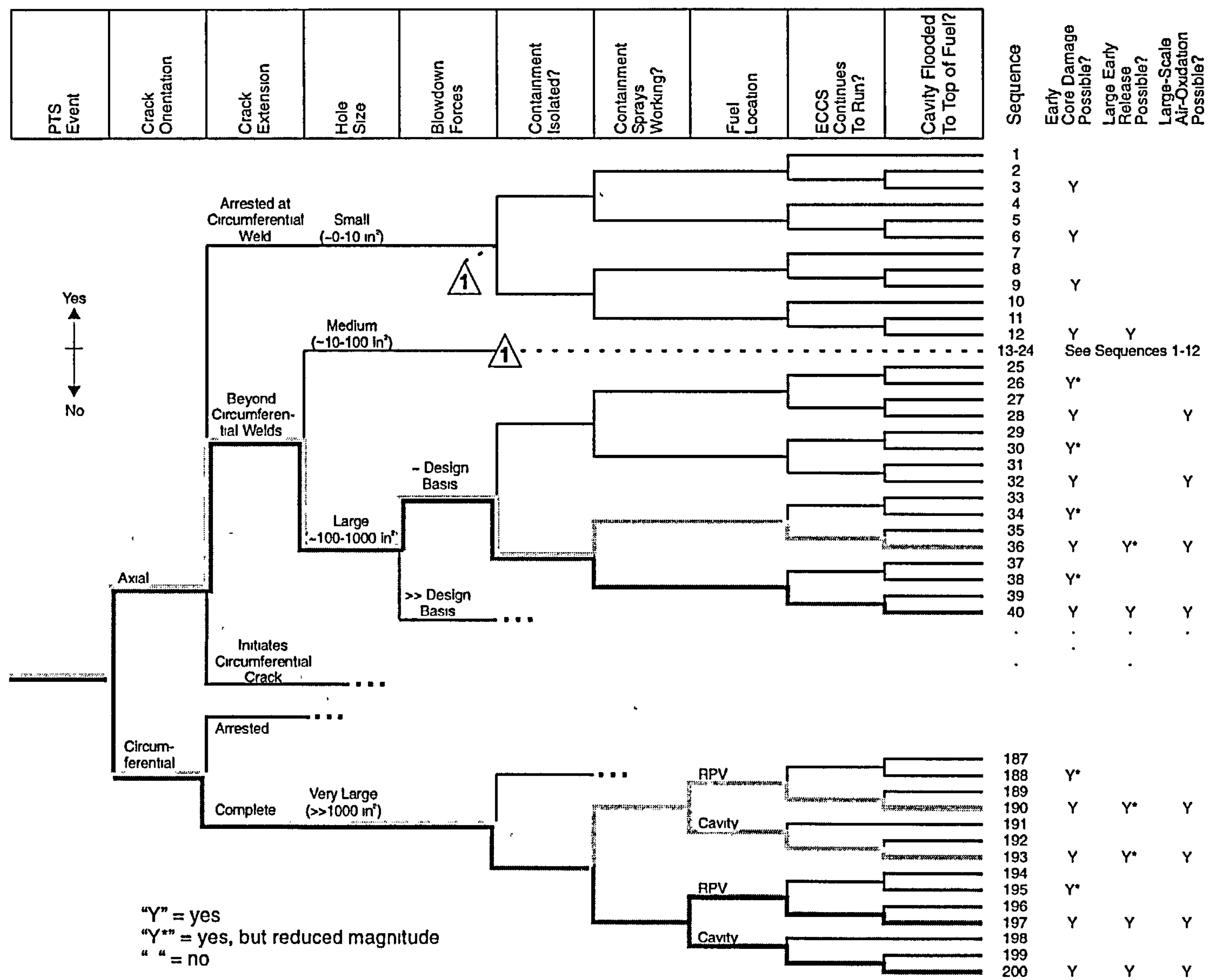
Scoping Study - Key Questions

- **Is a PTS-induced RPV failure likely to lead to melted fuel?**
- **Is a PTS-induced RPV failure likely to lead to a large, early release?**
- **Is the release spectrum (frequency-consequence) for PTS-induced large, early releases significantly worse than that associated with risk-significant, non-PTS-induced scenarios?**

Scoping Study - Approach

- **Refine SECY-02-0092 list of technical issues**
- **Develop accident progression event tree (APET) to support identification, representation and discussion of technical issues**
- **Evaluate current state of knowledge regarding technical issues**
- **Context for evaluations:**
  - **Focus on pilot plants; some consideration of plants addressed in generalization task**
  - **Whether/how PTS changes accident progression**

Accident Progression Event Tree (APET)



"Y" = yes
"Y*" = yes, but reduced magnitude
" " = no

Potential Sources of Dependence Between Top Events

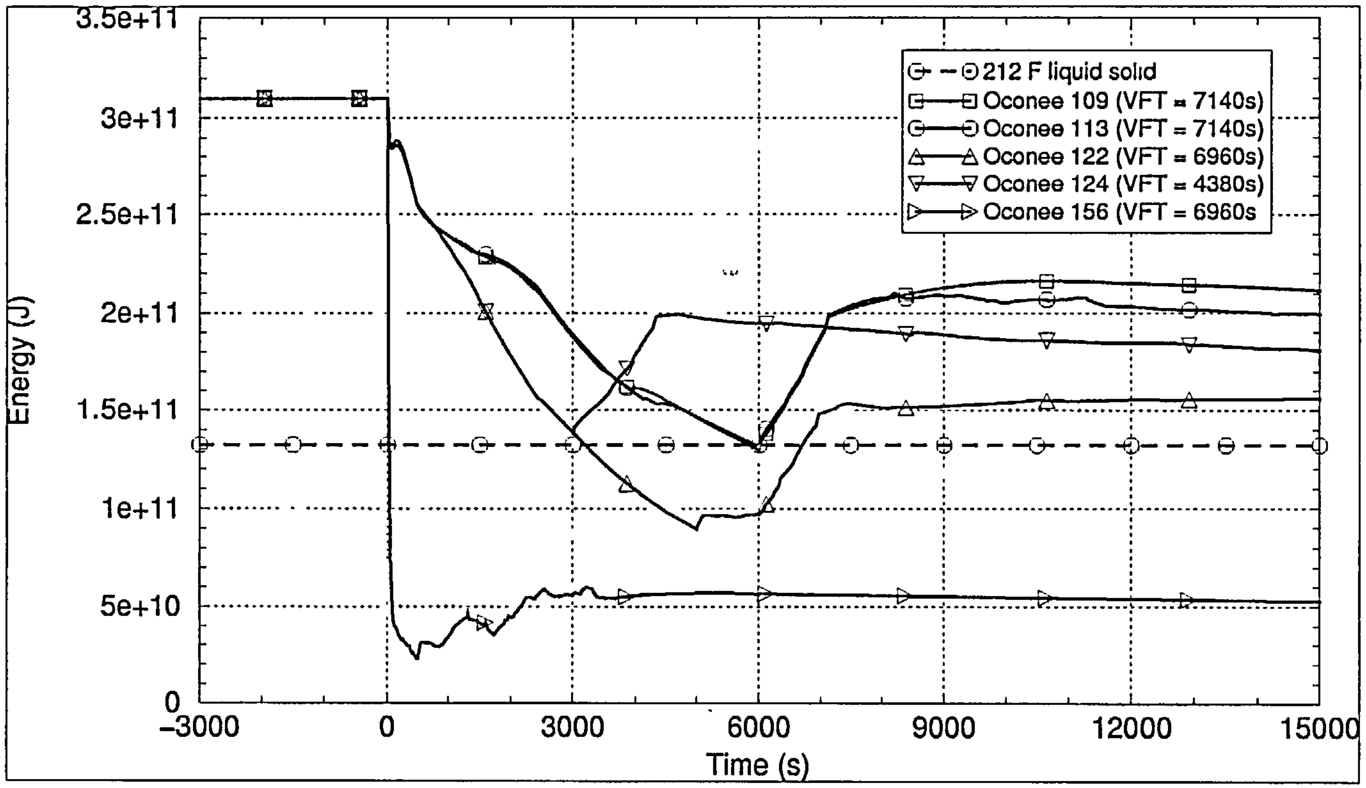
- **Plant systems**
- **RPV movement**
- **Fragments**
- **Fuel movement**

Plant Conditions at RPV Failure

- **Power available, cooling systems running (injection mode)**
- **LOCA events: RCS cooling, depressurizing**
  - **MLOCA - RPV failure at ~15-30 min (40 EFPY)**
  - **LLOCA - RPV failure at ~5-10 min (40 EFPY)**
- **Stuck-open SRV events: RCS at SRV setpoint**

  RPV failure at ~60-120 min (40 EFPY)

Blowdown Potential After RPV Failure



Conditions at RPV Failure

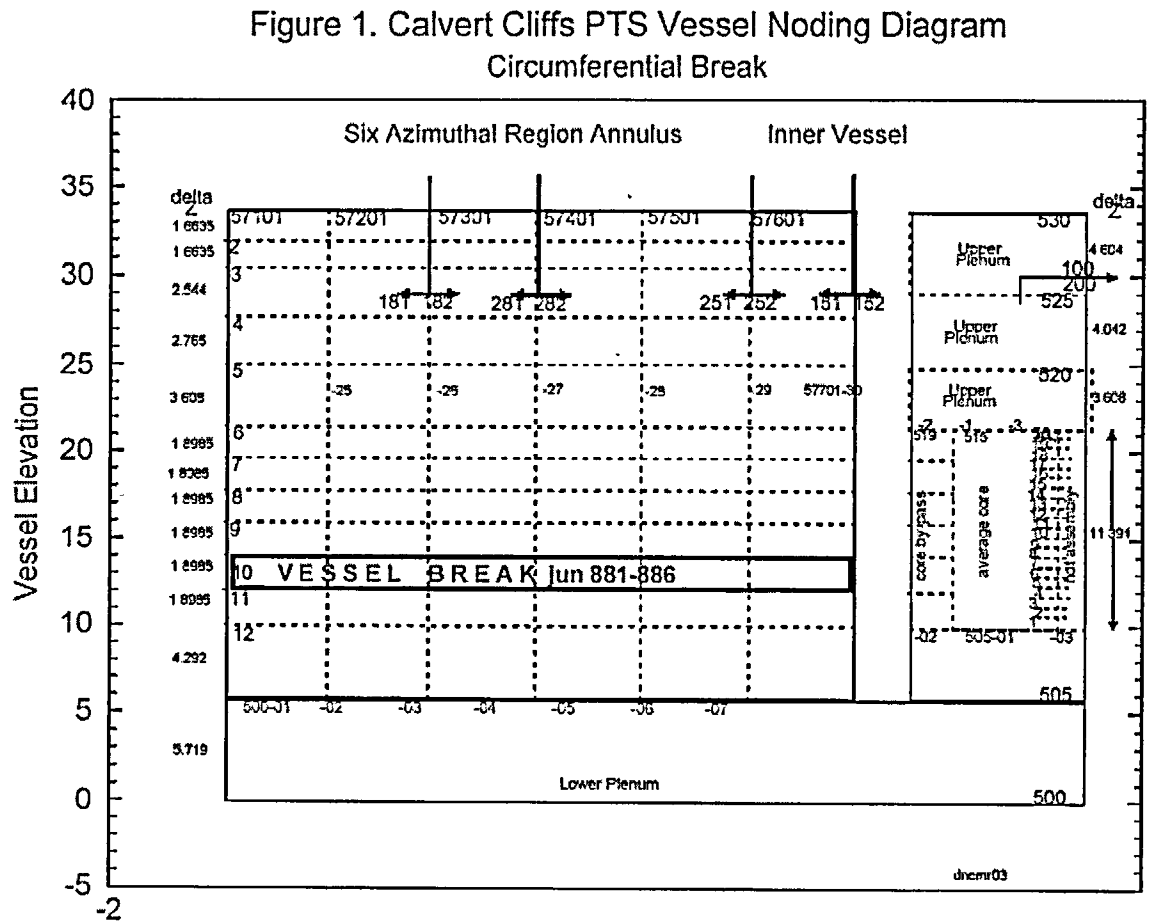
Transient	Break Time (s)	Pressure (psi)	Downcomer Temperature (F)	Specific Enthalpy (Btu/lbm)
4-inch surge line break	2400	200	215 (saturated)	183
Stuck open SRV	8230	2400	355	327
LB LOCA	0	2250	545	543

RPV TH Failure Analysis

- **Scoping calculations performed using RELAP5/MOD3.3 of RPV failure for Calvert Cliffs**
- **Two transients analyzed**
  - **4-inch surge line break**
  - **Stuck open pressurizer safety valves (2) that reclose at 6000s**
- **For each transient, two RPV failure modes analyzed**
  - **12 ft^2 axial break (1 ft x 12 ft)**
  - **360° circumferential break**
- **For each break, three break opening times analyzed**
  - **0.01 s**
  - **0.1 s**
  - **1 s**
- **Results compared to Design Basis LBLOCA**

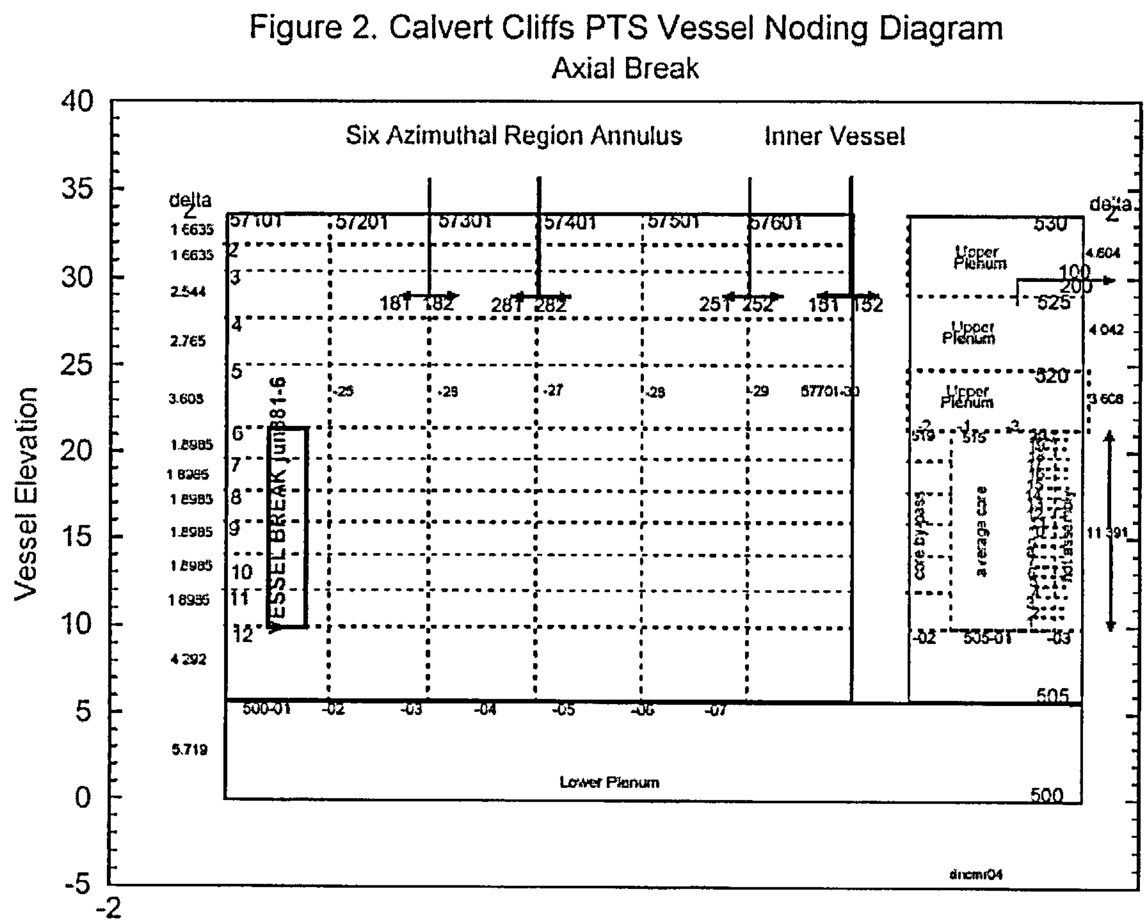
RPV TH Failure Analysis

Circumferential Break Nodalization



RPV TH Failure Analysis

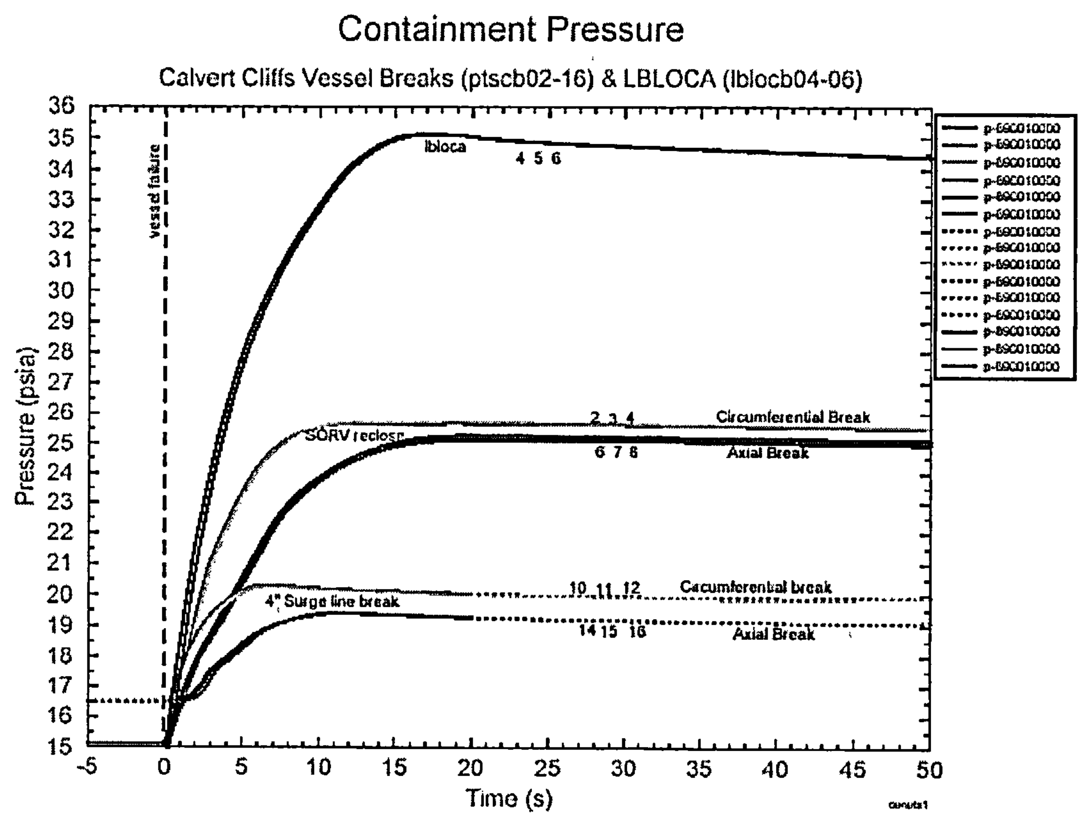
Axial Break Nodalization

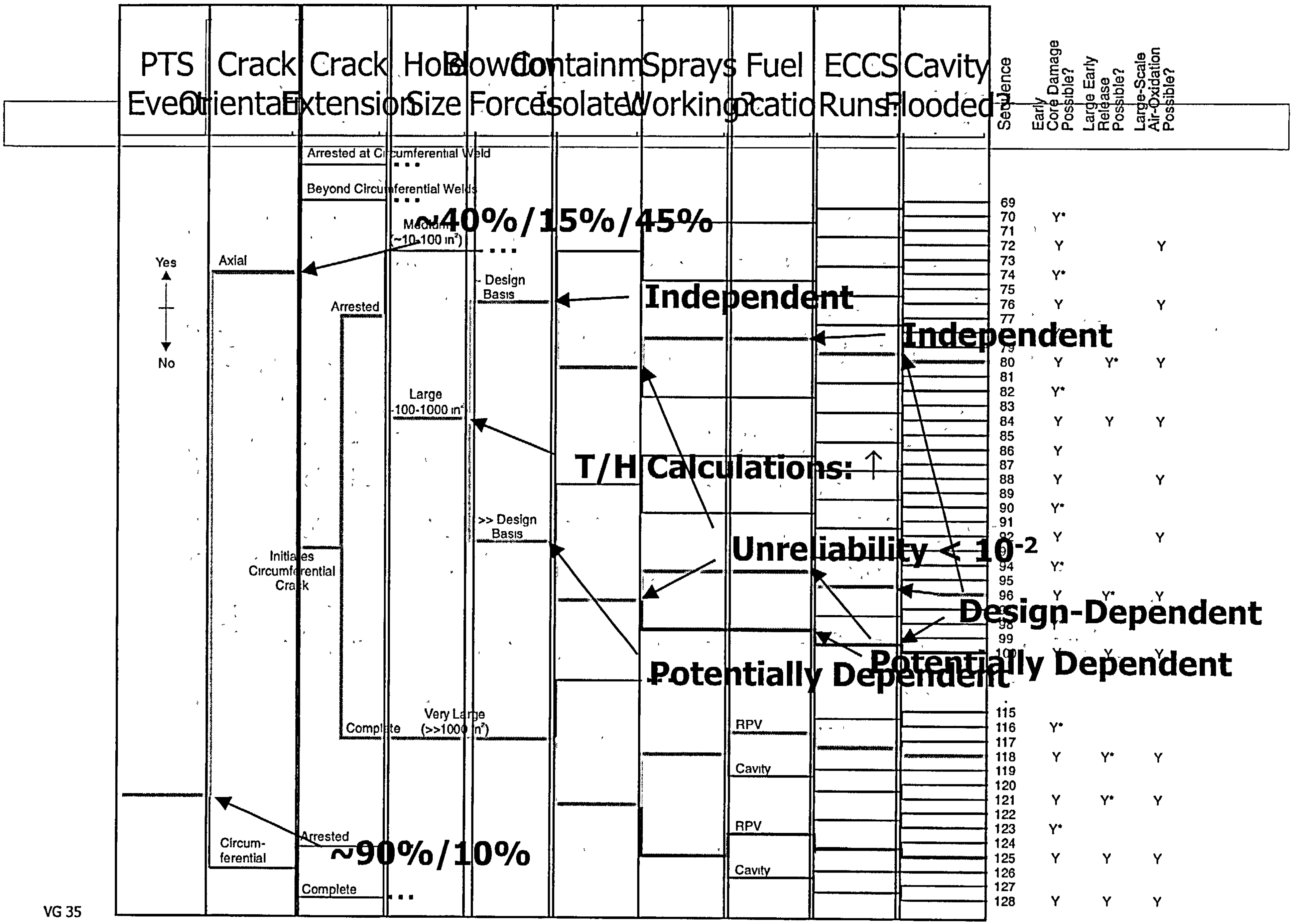


Internal Pressure Differentials

Transient	Vessel Break		Core Barrel ΔP (psi)	Core ΔP (psi)	Downcomer ΔP (psi)	Duration
4-inch surge line break	Axial	10ms 1s	150 15	60 -10	150 25	12-30 ms 1 s
	Circ	10ms 1s	165 45	110 30	35 15	20-70 ms 1 s
Stuck open SRV	Axial	10ms 1s	1800 50	600 -10	1680 40	10-20 ms 130 ms
	Circ	10ms 1s	2140 240	1460 100	50 -15	10-20 ms 60 ms
LB LOCA	N/A	10ms 1s	1010 -170	240 -70	1110 -500	

Containment Pressure




PTS Event
Crack Orientation
Crack Extension
Hole Size
Blowdown Forces
Containment Isolated
Sprays Working?
Fuel Location
ECCS Runs
Cavity Flooded?
Sequence
Early Core Damage Possible?
Large Early Release Possible?
Large-Scale Air-Oxidation Possible?
Arrested at Circumferential Weld
Beyond Circumferential Welds
~40%/15%/45%
Medium (~10-100 in²)
Yes
No
Axial
Design Basis
Independent
Independent
Arrested
Large 100-1000 in²
T/H Calculations: ↑
>> Design Basis
Unreliability < 10⁻²
Initiates Circumferential Crack
Design-Dependent
Potentially Dependent
Potentially Dependent
Complete
Very Large (>>1000 in²)
RPV
Cavity
RPV
Cavity
Circum-ferential
Arrested
~90%/10%
Complete
69
70 Y*
71
72 Y Y
73
74 Y*
75
76 Y Y
77
80 Y Y* Y
81
82 Y*
83
84 Y Y Y
85
86 Y
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99
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116 Y*
117
118 Y Y* Y
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120
121 Y Y* Y
122
123 Y*
124
125 Y Y Y
126
127
128 Y Y Y

Observations

- Accident energetics are more benign than those of some other scenarios previously studied (e.g., HPME)
- Containment pressurization likely to be less than design basis LOCA
- Blowdown forces on RPV and internals likely to be the same order of magnitude or bounded by DB LOCA
- Containment spray failure probability may decrease for PTS events (as compared with non-PTS risk-significant accidents)*
- Likelihood of fuel cooling dependent on reactor cavity design
  - Cavity flooding above top of fuel expected for some plants
  - For other plants, ECCS may not be sufficient to cool fuel

*For some plants, this may be dependent on plant changes in response to GSI-191.

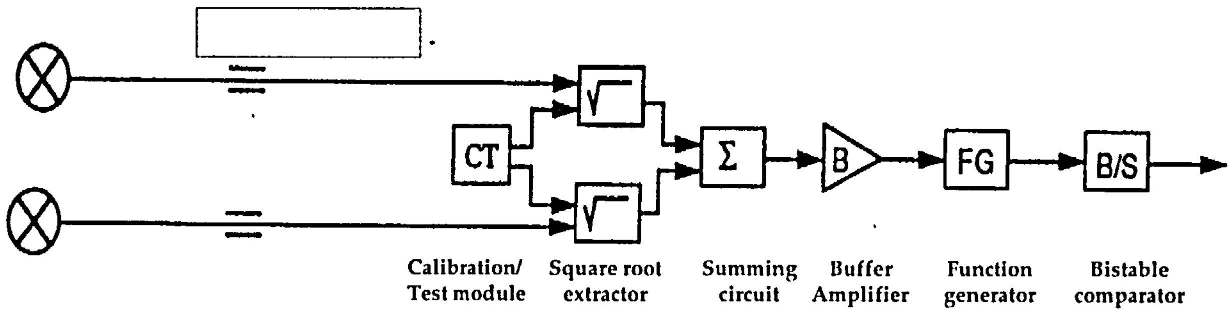
Scoping Study Conclusions

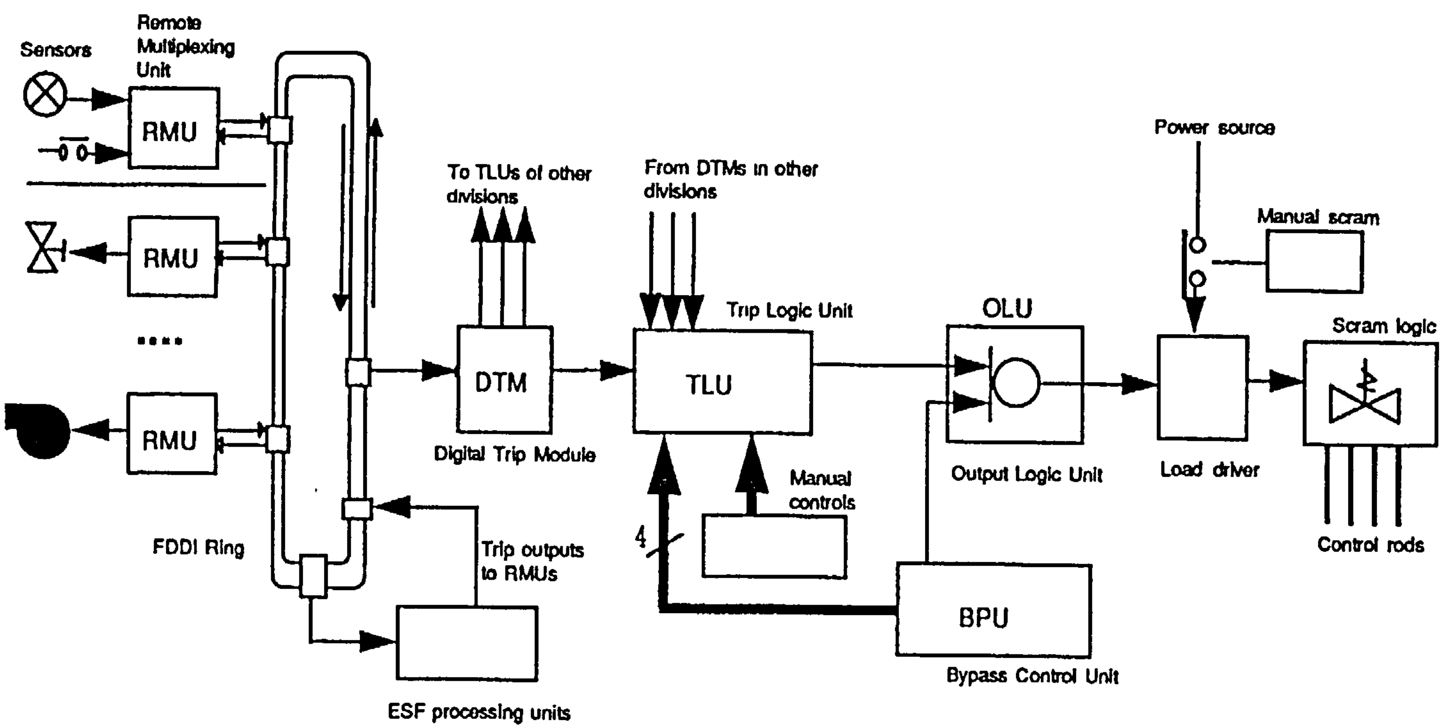
- The conditional probability of early fuel damage (given a PTS-induced RPV failure) appears to be
  - Extremely small for plants with cavities likely to be flooded
  - Non-negligible for other plants
- The conditional probability of early containment failure and a large, early release (given a PTS-induced RPV failure) appears to be very small for all plants
- Should a PTS-induced large, early release occur, such a release may involve a large-scale air-oxidation source term

Implications for RVFF*

- **RVFF* = 1 x 10^{-6}/ry is consistent with philosophy of original PTS rule, with ACRS guidance, and with Safety Goal Policy Statement**
  - **Assures a low level of risk associated with PTS events**
  - **Assures small relative contribution to acceptable risk**
  - **More limiting with respect to core damage than RG 1.174/Option 3 criterion for CDF**
  - **Consistent or conservative with respect to QHOs**
- **Expectation: RPV embrittlement limits will be established in a risk-informed manner**

Microprocessor-Based Equipment is Electrical Equipment or Systems That Use a Microprocessor





Overview of DG-1077

Guidelines for Environmental Qualification of Microprocessor-Based Equipment Important to Safety in Nuclear Power Plants

Christina E. Antonescu
Engineering Research Applications Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

Richard T. Wood and Kofi Korsah
Oak Ridge National Laboratory

Presented to

Advisory Committee on Reactor Safeguards

Rockville, Maryland

February 6, 2003

Outline of Presentation

- Overview of DG-1077
- Technical Basis for Environmental Qualification of Microprocessor-Based Equipment
- Summary of DG-1077 Benefits and Value

DG-1077 Endorses Current Environmental Qualification Standards for Safety-Related Microprocessor-Based Systems

- The proposed position endorses the guidance in IEEE 323-1983 (reaffirmed in 1996) for the qualification of safety-related microprocessor-based equipment for service in nuclear power plants subject to conditions and clarifications
- Endorsement of the guidance in IEC 60780 (1998) is introduced
- DG-1077 applies to new or modified safety-related systems in existing and future nuclear power plants that employ microprocessor-based equipment

Why is DG-1077 Needed?

- Responds to NRR User Need Request 2002-017
- Unique characteristics of microprocessor-based equipment (functional and hardware) should be addressed
- No existing endorsement of current national or international consensus standards on environmental qualification
- No comprehensive regulatory guide defining approach to qualification for all environmental conditions (mild as well as harsh)
- Potential regulatory burden arises from case-by-case treatment of qualification for mild environments

Resolution of Public Comments

- Eleven correspondents submitted comments on DG-1077
- Public comments can be grouped into general categories
  - Need for Guidance
  - Application of location categories
  - Scope of qualification
  - Backfit analysis
- DG-1077, Rev. 1, reflects resolution of comments

Technical Basis For Qualification Of Safety-Related Microprocessor-Based Equipment

The Code of Federal Regulations, Title 10, Part 50 Requires Environmental Qualification of Safety-Related Systems

- Structures, systems, and components important to safety must be designed to accommodate the effects of environmental conditions and design control measures such as testing must be used to verify the adequacy of the design
  - Part 50.55a(h), Codes and Standards, Protection Systems
    - Provides embedded requirement for environmental qualification of all systems important to safety (e.g., Section 5.4 of IEEE 603)
  - Part 50.49, Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants
    - Provides requirement for environmental qualification of electric equipment important to safety that are to be implemented in harsh environments
  - General Design Criteria 1, 2, 4, 13 and 23 in Appendix A
  - Criterion III, XI, and XVII in Appendix B

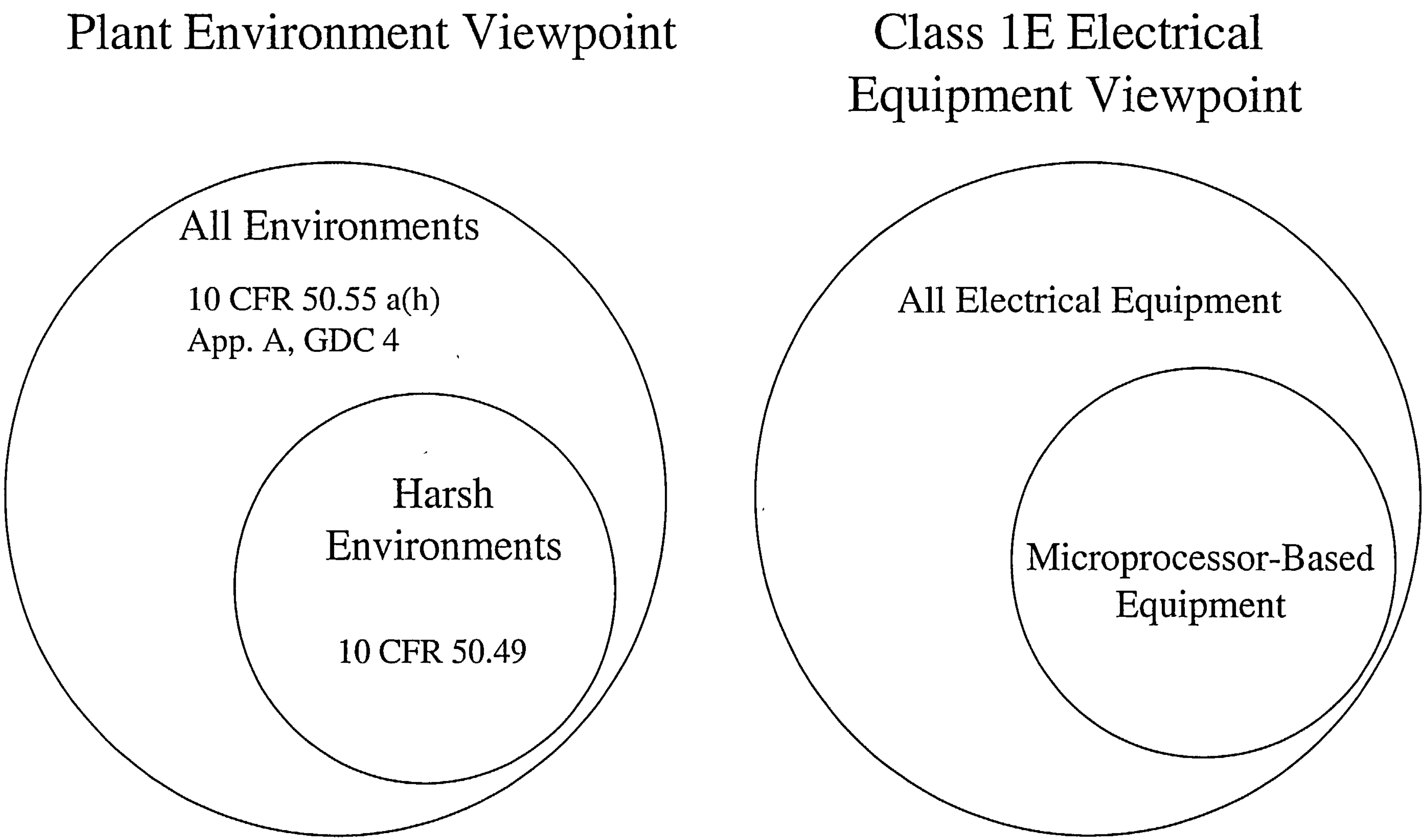
Existing Regulatory Guidance on Environmental Qualification Distributed Among Several Resources

- Regulatory Guide 1.89
  - Addresses 10 CFR 50.49 for electrical equipment important to safety
  - Limits scope to harsh environments that are subject to Design Basis Accident (DBA) conditions
  - Endorses IEEE 323
- NUREG-0588
  - Provides NRC Staff position on environmental qualification of safety-related electrical equipment
  - Applies to qualification based on IEEE 323
  - Describes equipment categories that includes mild environment applications (equipment not subject to DBA)
  - States qualification for mild environment should be supported by test or test and analysis

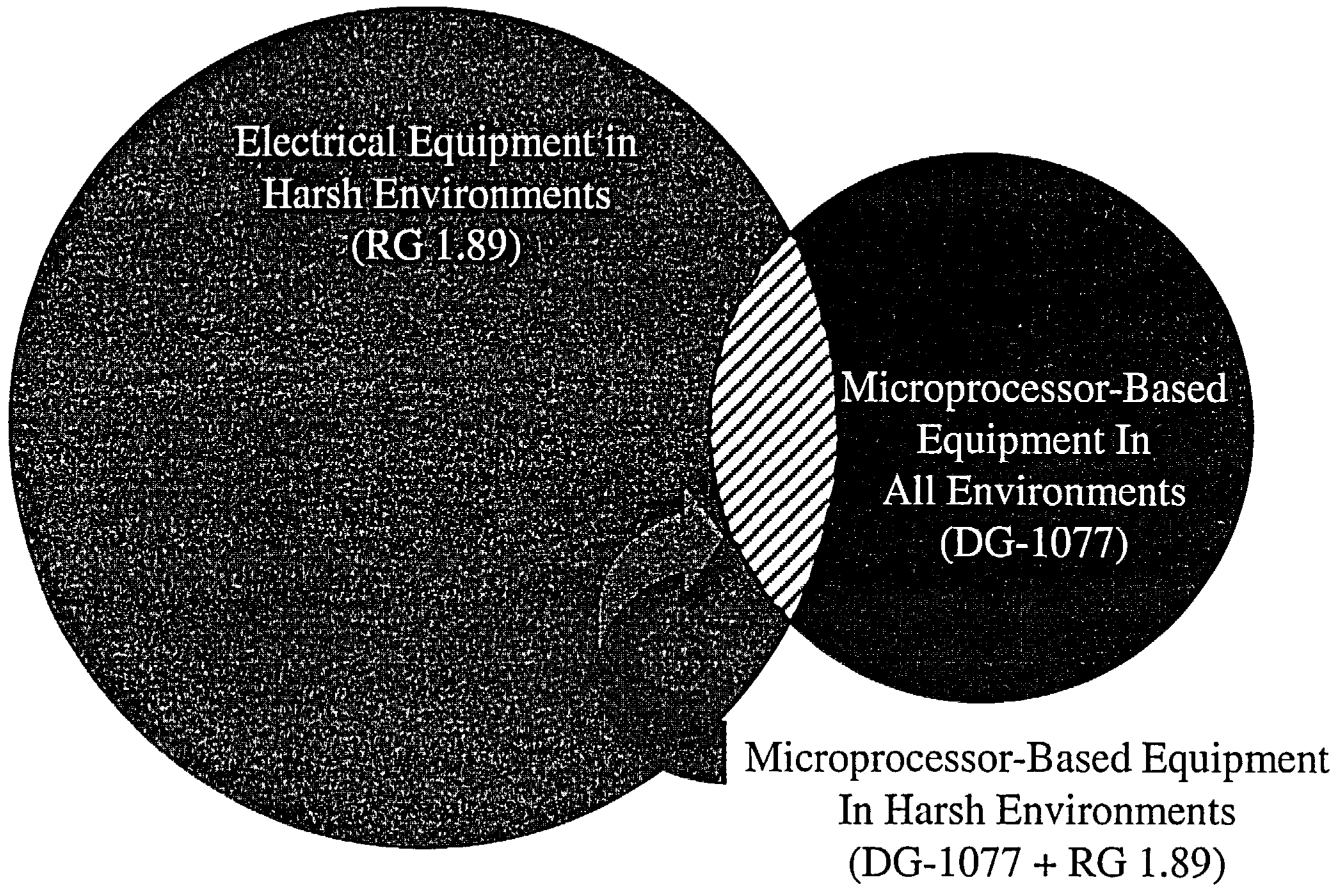
Existing Regulatory Guidance on Environmental Qualification Distributed Among Several Resources (cont)

- NUREG-0800, Chapter 7
  - Provides review guidance to NRC Staff on environmental qualification of safety-related instrumentation and controls equipment
  - References design criteria from IEEE 7-4.3.2
  - Specifies qualification for mild environments according to IEEE 323
  - States testing of channel or system "as a whole" is preferred but notes that licensee should confirm conservative design if testing not practical
- DG-1077 is intended to provide a roadmap for existing guidance that is applicable to microprocessor-based equipment

Environmental Qualification Can Be Viewed According To Two Perspectives



Environmental Qualification Role for DG-1077



There Are Several Unique Functional and Hardware Characteristics of Microprocessor-Based Equipment

- High functional density
- Sequential execution of function
- Radiation tolerance
- Increased level of complexity and higher circuit density
- Higher clock speeds and lower logic voltages

DG-1077 Endorses Current Environmental Qualification Standards for Safety-Related Microprocessor-Based Systems

- Either IEEE 323-1983 or IEC 60780 are appropriate for satisfying the qualification of safety-related microprocessor-based equipment for service in nuclear power plants subject to conditions and clarifications

Key Positions in DG-1077

- Environmental qualification of microprocessor-based equipment should address unique characteristics
  - During type testing, equipment should be functioning with operational activities being performed
  - Dynamic response of a distributed system under environmental stress should be considered during qualification testing
- Electromagnetic compatibility testing (i.e., EMI/RFI susceptibility and surge withstand testing) should be included as part of qualification testing:
  - Should be performed as part of the test sequence per IEC 60780, or at an equivalent stage of the test sequence under IEEE 323-1983, if that standard is being applied

Application of DG-1077 Location Categories

- Location Categories Are Employed to Streamline the Initial Determination of the Need to Address Aging in Type Testing
- Category A Locations Correspond to 10 CFR 50.49 Locations
  - Traditional aging factors must be accounted for in qualification
- Category C Locations Correspond to Areas That Employ Environmental Control
  - Traditional aging factors are not necessary as a step in qualification
- Category B Locations Correspond to All Other Areas
  - An assessment of the need for addressing traditional aging factors is a necessary step in qualification

Key Positions in DG-1077 (cont)

- Equipment intended for Category A Locations:
  - Aging must be addressed in type testing (e.g., preconditioning is a necessary part of the test sequence)
  - RG 1.89 guidance for harsh environments is incorporated by reference into DG-1077 (i.e., the exceptions and clarifications specified in RG 1.89 apply)
  - Qualification of microprocessor-based equipment may be in accordance with either IEEE 323-1983 or IEC 60780

Key Positions in DG-1077 (cont)

- Equipment intended for Category B Locations:
  - Need to address aging in type testing should be based on an assessment of any aging mechanisms that may have significant effects on the expected life of the equipment
  - Documentation of age conditioning or the findings of the assessment of aging mechanisms should be provided
- Equipment intended for Category C Locations:
  - Aging does not need to be addressed in type testing
  - Documentation of age conditioning may be omitted

Key Positions in DG-1077 (cont)

- Margin should be applied in accordance with the standard being used with the following addition:
  - Temperature margin for conditions other than saturated steam conditions is identified to supplement IEC 60780 guidance on suggested margin factors

Suggested Considerations for Environmental Compatibility Were Deleted in Response to Public Comments

- Standards and test practices used by IC manufacturers for component stress testing can be identified and listed for each supplier to ensure the use of quality components is maintained
  - Temperature/humidity bias tests (moisture resistance for plastic encapsulated devices)
  - High temperature operating life test (accelerates temperature-related failures)
  - Temperature cycle test (accelerates thermal expansion mismatch)
  - Autoclave test (moisture resistance and resultant galvanic corrosion)
  - Low temperature operating life test (accelerates failures due to MOS device parameter changes)
  - System soft error test (measures actual system soft error performance

Suggested Considerations for Environmental Compatibility Were Deleted in Response to Public Comments (cont)

- Multi-tiered protection approaches (based on design/configuration) can be identified to supplement evidence of environmental compatibility
  - Electronic component level
  - Module or circuit board level
  - Cabinet level
  - Room level

Suggested Considerations for Environmental Compatibility Were Deleted in Response to Public Comments (cont)

- Any life-limited component of the microprocessor-based system being qualified should be identified and its operational-life should be documented
- Random failures and degradation in hardware performance (e.g., reduced noise margin) should be addressed using surveillance, on-line diagnostics, maintenance, and/or trending techniques at intervals based on the predicted failure rates. The use of on-line approaches should avoid diagnostic algorithms/procedures that are so complex that their failure could cause more faults than they prevent

Summary of DG-1077
Benefits and Value

Benefits of DG-1077

- Explicit guidance on an acceptable method for environmental qualification of safety-related microprocessor-based equipment
- Endorsement of current national and international qualification standards
- Specific guidance to address the unique characteristics of microprocessor technology
  - Need to operate the equipment as it is tested by performing full range of functions
  - Need to evaluate dynamic response of distributed system under environmental stress
- Streamlined approach to the initial determination of whether aging is necessary as part of qualification
  - Designation of plant locations that clearly do not require aging as part of qualification by type test

Public Comments Contributed to Improved Clarity and Sharpened Focus For Revised Draft Regulatory Guide

- Comments expressed support for endorsement of current environmental qualification standards (IEEE 323-1983 and IEC 60780)
- Comments indicated presentation of regulatory position and discussion of technical basis needed improvement
- Comments indicated some uncertainty about scope and purpose of environmental qualification
- Some positions in the guide suggesting supplemental information supporting environmental compatibility were misinterpreted as additional requirements

Final Effective Guide Will Support NRC Mission

- Contributes to Achieving NRC Goals
  - Maintaining Safety by providing an approach for verifying that environmental stress will not hinder the performance of safety-related functions by microprocessor-based equipment
  - Reducing Regulatory Burden by minimizing potential regulatory uncertainty and streamlining the determination of necessary qualification steps
  - Improving Regulatory Effectiveness by giving explicit guidance on acceptable practices for environmental qualification that utilize current standards and address the unique characteristics of microprocessor-based equipment